THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

Art. XXXIII.—*On the Aboriginal Monuments and Relics of New York;* by E. G. Squier, A.M.*

GENERAL OBSERVATIONS ON THE ABORIGINAL MONUMENTS OF THE STATE OF NEW YORK.†

The Indian tribes found in possession of the country now embraced within the limits of New England and the Middle States have left few monuments to attest their former presence. The fragile structures which they erected for protection and defense have long ago crumbled to the earth; and the sites of their ancient towns and villages are indicated only by the ashes of their long-extinguished fires, and by the few rude relics which

* We cite here a few pages from a work by Mr. Squier, just published by the Smithsonian Institution, entitled, Aboriginal Monuments of the State of New York, comprising the results of original surveys and explorations, (188 pp. 4to, with 14 plates and numerous wood-cuts.) The researches in New York were undertaken in 1848, under the joint auspices of the Smithsonian Institution and the Historical Society of New York, and the work contains the results arrived at. The various monuments of the several counties of the state are described with detail, as far as known, their uses and history described, and other topics bearing upon the customs of their builders are treated of with much learning and discrimination. An Appendix contains general conclusions with regard to the Indians and their works, drawn from the various investigations which have been made over the continent. In our citations from the work, we pass by a large amount of detail of great interest well illustrated by the plates and sketches, and give but a partial view of the various results brought out in the work—referring the reader to the work itself for a complete account of the author's observations and deductions. Many points are illustrated with fullness and beauty in Mr. Squier's earlier work on "the Ancient Monuments of the Mississippi Valley," published in 1848, as the first volume of the Smithsonian Contributions to Knowledge in a 4to volume of 300 pages.

† Pages 9–13.

the plough of the invader exposes to his curious gaze. Their cemeteries, marked in very rare instances by enduring monuments, are now undistinguishable, except where the hand of modern improvement encroaches upon the sanctity of the grave. The forest-trees, upon the smooth bark of which the Indian hunter commemorated his exploits in war, or success in the chase —the first rude efforts towards a written language—have withered in the lapse of time, or fallen beneath the inexorable axe. The rock upon which the same primitive historian laboriously wrought out his rude but to him significant picture, alone resists the corrosion of years. Perhaps no people equally numerous have passed away without leaving more decided memorials of their former existence. Excepting the significant names of their sonorous language, which still attach to our mountains, lakes, and streams, little remains to recall the memory of the departed race.

But notwithstanding the almost entire absence of monuments of art clearly referable to the Indian tribes discovered in the actual possession of the region above indicated, it has long been known that many evidences of ancient labor and skill are to be found in the western parts of New York and Pennsylvania, upon the upper tributaries of the Ohio, and along the shores of Lakes Erie and Ontario. Here we find a series of ancient earth-works, entrenched hills, and occasional mounds or tumuli, concerning which history is mute, and the origin of which has been regarded as involved in impenetrable mystery. These remains became a subject of frequent remark, as the tide of emigration flowed westward; and from time to time, various detached notices of their existence were made public. No connected view, however, of their extent or character was given to the world, until 1817, when De Witt Clinton, whose energetic mind neglected no department of inquiry, read a brief memoir upon the subject before the "Literary and Philosophical Society of New York," which was published in pamphlet form, at Albany, in 1818. Mr. Clinton in this memoir did not profess to give a complete view of the matter; his aim being, in his own language, "to awaken the public mind to a subject of great importance, before the means of investigation were entirely lost." It consequently contains but little more than notices of such ancient earth-works, and other interesting remains of antiquity, as had at that time fallen under his notice, or of which he had received some distinct information. Its publication, however, was without any immediate effect; for few individuals, at that period, felt the interest requisite, or possessed the opportunities necessary, for the continuance of the investigations thus worthily commenced. Nothing further, it is believed, appeared upon the subject, until the publication of McCauley's History of New York, in 1828. This

work contained a chapter upon the antiquities of the state, embodying the essential parts of Mr. Clinton's memoir, together with some facts of considerable interest, which had fallen under the observation of the author himself. Within a few years, public attention has again been directed to the subject by Mr. Schoolcraft, in his "Notes on the Iroquois." Some detached facts have also been presented in local histories and publications, but usually in so loose and vague a manner as to be of little value for purposes of comparison and research.

The observations of all these authorities were merely incidental, and were limited in their range. By none were presented plans from actual surveys of any of the ancient works of the state; a deficiency which, it is evident, could not be supplied by descriptions, however full and accurate, and without which it has been found impossible to institute the comparisons requisite to correct conclusions as to the date, origin, and probable connections of these remains. It has all along been represented that some of the enclosures were of regular outlines, true circles and ellipses and accurate squares—features which would imply a common origin with the vast system of ancient earth-works of the Mississippi valley. Submitted to the test of actual survey, I have found that the works which were esteemed entirely regular are the very reverse, and that the builders, instead of constructing them upon geometrical principles, regulated their forms entirely by the nature of the ground upon which they were built. And I may here mention, that none of the ancient works of this state, of which traces remain displaying any considerable degree of regularity, can lay claim to high antiquity. All of them may be referred with certainty to the period succeeding the commencement of European intercourse.

Mr. Clinton was unable to learn of the occurrence of any remains upon the first terrace back from the lakes, and, upon the basis of the assumed fact of their non-existence, advanced the opinion that the subsidence of the lakes and the formation of this terrace had taken place since these works were erected—a chronological period which I shall not attempt to measure by years. This deduction has been received, I believe, by every succeeding writer upon the subject of our antiquities, without any attempt to verify the assumption upon which it rests. I have, however, found that the works occur indiscriminately upon the first and upon the superior terraces, as also upon the islands of the lakes and rivers.

Misled by statements which no opportunity was afforded of verifying, I have elsewhere, though in a guarded manner, ventured the opinion that the ancient remains of western New York belonged to the same system with those of Ohio and the West generally. Under this hypothesis, the question whether they

were the weaker efforts of a colony, starting from the south-western centres, or the ruder beginnings of a people just emerging from a nomadic state, becoming fixed in their habits, and subsequently migrating southward, next suggested itself; and I gladly availed myself of the joint liberality of the Smithsonian Institution and the Historical Society of New York, to undertake its investigation. The results of my observations are briefly presented in the following pages. These observations extended from the county of St. Lawrence on the north, to Chautauque on the south, embracing the counties of Jefferson, Oswego, Onondaga, Oneida, Cayuga, Seneca, Ontario, Wayne, Monroe, Livingston, Orleans, Niagara, Erie, Genesee, and Wyoming. Throughout this entire region, ancient remains are found in considerable abundance; they are also occasionally found in the counties adjoining those above named, upon the principal tributaries of the Delaware, Susquehannah, and Alleghany. They are known to extend down the Susquehannah, as far as the valley of the Wyoming; and a single one was discovered as far east as Montgomery county, in the neighborhood of Fort Plain. Some, it is said, are found in Canada; but no definite information was received of their localities. It is to be observed that they are most numerous in sections remarkable for their fertility of soil, their proximity to favorable hunting and fishing grounds—in short, possessing the greatest number of requisites to easy subsistence. They are particularly numerous in Jefferson county, in the vicinity of the central lakes, in the southern part of Monroe, in Livingston, Genesee, and Erie counties. Many are said to exist in Chautauque; but the lateness of the season, and the unsuspected number of remains elsewhere claiming attention, prevented me from examining them.

In respect to the number of these remains, some estimate may be formed from the fact that, in Jefferson county alone, *fifteen* enclosures were found, sufficiently well preserved to admit of being traced throughout. This is exclusive of those (probably a greater number) which have been wholly or in part destroyed, or of which no information could be obtained, in the limited time allotted to the investigation of that county. It is safe to estimate the whole number which originally existed here at between thirty and forty—a greater number than was before known to exist in the state. Erie county probably contained nearly as many. In the short period of eight weeks devoted to the search, I was enabled to ascertain the localities of not less than one hundred ancient works, and to visit and make surveys of half that number. From the facts which have fallen under my notice, I feel warranted in estimating the number which originally existed in the state at from two hundred to two hundred and fifty. Probably one half of these have been obliterated by the plough, or so much encroached upon as to be no longer satisfactorily traced.

Were these works of the general large dimensions of those of the Western states, their numbers would be a just ground of astonishment. They are, however, for the most part, comparatively small, varying from one to four acres,—the largest not exceeding sixteen acres in area. The embankments, too, are slight, and the ditches shallow; the former seldom more than four feet in height, and the latter of corresponding proportions. The work most distinctly marked exists in the town of Oakfield, Genesee county; it measures, in some places, between seven and eight feet from the bottom of the ditch to the top of the wall. In some cases the embankment is not more than a foot in height, and the trench of the same depth. Lest it should be doubted whether works so slight can be satisfactorily traced, it may be observed, that a regular and continuous elevation of six inches may always be followed without difficulty.

In respect of position, a very great uniformity is to be observed throughout. Most occupy high and commanding sites near the bluff edges of the broad terraces by which the country rises from the level of the lakes. From the brows of the limestone ledges where some of these works occur, in Jefferson and Erie counties, most extensive prospects may be obtained, often terminating in the blue belt of the lakes, distant from ten to forty miles; the intervening country presenting a beautiful variety of cleared and forest lands, dotted with houses, churches, and villages. When found upon lower grounds, it is usually upon some dry knoll or little hill, or where banks of streams serve to lend security to the position. A few have been found upon slight elevations in the midst of swamps, where dense forests and almost impassable marshes protected them from discovery and attack. In nearly all cases they are placed in close proximity to some unfailing supply of water, near copious springs or running streams. Gateways, opening toward these, are always to be observed, and in some cases guarded passages are also visible. These circumstances, in connection with others not less unequivocal, indicate, with great precision, the purposes for which these structures were erected.

It has already been mentioned that Messrs. Clinton, Yates, and Moulton, and others, have concluded, upon the assumption that none of these works occur upon the first and second terraces above the lakes, that the latter have subsided to the present level since their erection. This conclusion does not necessarily follow from the premises. Few positions susceptible of defense, under the system practised by all rude people, are to be found upon either of these terraces; the builders, consequently, availed themselves of the numerous headlands and other defensible positions which border the supposed ancient shores of the lakes, simply because they afforded the most effectual protection, with the least expenditure of labor.

I found an entire uniformity in the indications of occupancy, and in the character of the remains of art discovered within these enclosures, throughout the whole range of their occurrence. The first feature which attracts notice, upon entering them, is a number of pits or excavations in the earth, usually at the points which are most elevated and dry. These pits are occasionally of considerable size, and are popularly called "wells," although nothing is more obvious than that they never could have been designed for any such purpose. They are usually from three to four, but sometimes from six to eight feet in depth, and of proportionate size at the top. Their purposes become sufficiently evident upon excavation. They were the *caches* in which the former occupants of these works deposited their stores. Parched corn, now completely carbonized by long exposure, is to be discovered in considerable abundance in many of them. Instances fell under my notice where it had been found untouched to the amount of bushels, in these primitive depositories. Traces of the bark and thin slips of wood, by which the deposits were surrounded, are also frequently to be found. In many of these enclosures the sites of the ancient lodges, or cabins, are still to be traced. These are marked by considerable accumulations of decomposed and carbonaceous matter—stones much burned, charcoal and ashes mingled with the bones of animals, with numerous fragments of pottery, broken pipes, and occasionally rude ornaments, such as beads of stone, bone, and shell. The pottery, I may observe incidentally, is of very good material, and appears to have been worked and ornamented with considerable taste and skill. It is found in great abundance; and, in many of the enclosures now under cultivation, bushels of fragments might, if desirable, be collected without difficulty. The material, in common with that of all the aboriginal pottery of the North, is composed of clay tempered (if I may use the term) with pounded quartz and shells, or with fine sand, so as to prevent shrinkage, and resist the action of fire. Most of it is well burned, but none exhibits any appearance of glazing. The pipes are mostly composed of clay, regularly and often fancifully moulded, and ornamented in various ways. Some bear the form of animals, the distinctive features of which are well preserved; others are moulded in the shape of the human head, or are variously fluted and dotted with regular figures. They are generally of very good material, the clay of fine quality, and well burned. Some, indeed, are so hard, smooth, and symmetrical, as almost to induce doubts of their aboriginal origin. Some of the terra cottas, other than pipes, are really very creditable specimens of art, and compare favorably with any of the productions of the aborigines which have fallen under my notice. They are, with few exceptions, representations of animals; with the minutest features, as

well as the peculiar habits of which, the American Indians had, from long observation, a thorough acquaintance.

CONCLUDING OBSERVATIONS ON THE NEW YORK MOUNDS.*

By whom were the aboriginal monuments of Western New York erected, and to what era may they be ascribed? The consideration of these questions has given rise to a vast amount of speculation, generally not of the most philosophical, nor yet of the most profitable kind. If the results arrived at have been erroneous, unsatisfactory, or extravagant, it may be ascribed to the circumstance that the facts heretofore collected have been too few in number, and too poorly authenticated, to admit of correct conclusions, not less than to the influence of preconceived notions, and to that constant leaning towards the marvellous, which is a radical defect of many minds. Rigid criticism is especially indispensable in archæological investigations; yet there is no department of human research in which so wide a range has been given to conjecture. Men seem to have indulged the belief that here nothing is fixed, nothing certain, and have turned aside into this field as one where the severer rules which elsewhere regulate philosophical research are not enforced, and where every species of extravagance may be indulged in with impunity. I might adduce numberless illustrations of this remark. The Indian who wrought the rude outlines upon the rock at Dighton, little dreamed that his work would ultimately come to be regarded as affording indubitable evidence of Hebrew, Phœnician, and Scandinavian adventure and colonization in America; and the builders of the rude defences of Western New York, as little suspected that Celt and Tartar, and even the apochryphal Madoc with his "ten ships," would, in this the nineteenth century of our faith, be vigorously invoked to yield paternity to their labors!

The probable purposes to which these works were applied are perhaps sufficiently evident from what has already been presented. Their positions, general close proximity to water, and other circumstances not less conclusive, imply a defensive origin. The unequivocal traces of long occupancy found within many of them, would further imply that they were fortified towns and villages, and were permanently occupied. Some of the smaller ones, on the other hand, seem rather designed for temporary protection,—the citadel in which the builders sought safety for their old men, women, and children, in case of alarm or attack.

In respect to date, nothing positive can be affirmed. Many of them are now covered with heavy forests; a circumstance upon which too much importance has been laid, and which in itself

* Pages 81–84.

may not necessarily be regarded as indicative of great age; for we may plausibly suppose that it was not essential to the purposes of the builders that the forests should be removed. Still I have seen trees from one to three feet in diameter standing upon the embankments and in the trenches; which would certainly carry back the date of their construction several hundred years, perhaps beyond the period of the discovery in the fifteenth century. There is nothing, however, in this circumstance, nor in any other bearing upon the subject, which would necessarily imply that they were built by tribes anterior to those found in occupation of the country by the whites. And this brings us at once to the most interesting point of our inquiry, viz.: *By whom were these works erected?*

I have already mentioned that within them are found many relics of art and many traces of occupancy. These, as I had ample opportunities of ascertaining in the course of my investigations, are absolutely *identical* with those which mark the sites of towns and forts known to have been occupied by the Indians, within the historical period. The pottery taken from these sites and from within the supposed ancient enclosures, is alike in all respects; the pipes and ornaments are undistinguishable: and the indications of aboriginal dwellings are precisely similar, and, so far as can be discovered, have equal claim to antiquity. Near many of these works are found cemeteries, in which well-preserved skeletons are contained, and which, except in the absence of remains of European art, differ in no essential respect from the cemeteries found in connection with the abandoned modern towns and "castles" of the Indians. There are other not less important facts and coincidences, all of which go to establish that if the earth-works of Western New York are of a remote ancient date, they were not only *secondarily* but *generally* occupied by the Iroquois or neighboring and contemporary nations; or else—and this hypothesis is most consistent and reasonable—they were erected by them.

The questions by whom were the aboriginal monuments of Western New York erected, and to what era may they be ascribed, have probably been answered to the satisfaction of every mind by the simple detail of facts in the preceeding chapters.

It may be objected that if the Indians constructed works of this kind, it could not have escaped the notice of the early explorers, and would have been made the subject of remark by them. The omission is singular, but not unaccountable. They all speak of the defences of the Indians as composed of palisades firmly set in the ground. The simple circumstance of the earth being heaped up around them, to lend them greater firmness, may have been regarded as so natural and simple an expedient, as not to be deserving of special mention, particularly as the em-

bankment, in such a case, would be an entirely subordinate part of the structure. After the introduction of European implements, enabling the Indians to plant their pickets more firmly in the ground, and to lend them a security before unattainable, the necessity for an embankment was in a great degree obviated. We may thus account for its absence in their later structures, which also underwent some modification of form, suggested by the example or instructions of the whites, or by the new mode of warfare following the introduction of fire-arms. Thus in the plan of the old Seneca fort of *Ganundasaga*, we find distinct traces of the bastion—a feature observable in none of the more ancient defences.

I am aware that the remnants of the Indian stock which still exist in this state, generally profess total ignorance of these works. I do not, however, attach much importance to this circumstance. When we consider the extreme likelihood of the forgetfulness of ancient practices, in the lapse of three hundred years, the lack of knowledge upon this point is the weakest of all negative evidence. Cusick, the Indian, in his so-called "History of the Six Nations," has, no doubt, correctly described the manner in which they constructed their early defences. "The manner of making a fort: First, they set fire against as many trees as it requires to make the enclosure, rubbing off the coals with their stone axes, so as to make them burn faster. When the tree falls, they put fires to it about three paces apart, and burn it into pieces. These pieces are then brought to the spot required, and set up around, according to the bigness of the fort. *The earth is then heaped on both sides.* The fort has generally two gates, one for passage and one to the water." "The people," continues Cusick, "had implements with which they made their bows and arrows. Their kettles were made of baked clay; their awls and needles of sharpened bones; their pipes of baked clay or soft stone; a small turtle-shell was used to peel the bark, and a small dry stick to make fire by boring it against seasoned wood."

Colden observes of their defences, as they were constructed in his time: "Their castles are generally a square surrounded with palisades, without any bastions or outworks; for, since the general peace, their villages all lie open."*

In full view of the facts before presented, I am driven to a conclusion little anticipated when I started upon my trip of exploration, that the earth-works of Western New York were erected by the Iroquois or their western neighbors, and do not possess an antiquity going very far back of the discovery. Their general occurrence upon a line parallel to and not far distant from the lakes, favors the hypothesis that they were built by frontier

* History of the Five Nations, vol. i, p. 9.

tribes—an hypothesis entirely conformable to aboriginal traditions. Here, according to these traditions, every foot of ground was contested between the Iroquois and the Gah-kwas and other western tribes; and here, as a consequence, where most exposed to attack, were permanent defences most necessary. It was not till after the Confederation, that the Five Nations were able to check and finally expel the warlike people which disputed with them the possession of the beautiful and fertile regions bordering the lakes; and it is not impossible that it was the pressure from this direction which led to that Confederation,—an anomaly in the history of the aborigines. Common danger, rather than a far-seeing policy, may be regarded as the impelling cause of the consolidation.

In conclusion, I may be permitted to observe, that the ancient remains of Western New York, except so far as they throw light upon the system of defence practised by the aboriginal inhabitants, and tend to show that they were to a degree fixed and agricultural in their habits, have slight bearing upon the grand ethnological and archæological questions involved in the ante-Columbian history of the continent. The resemblances which they bear to the defensive structures of other rude nations, in various parts of the world, are the result of natural causes, and cannot be taken to indicate either a close or remote connection or dependence. All primitive defences, being designed to resist common modes of attack, are essentially the same in their principles, and seldom differ much in their details. The aboriginal hunter and the semi-civilized Aztec, selected precisely similar positions for their fortresses, and defended them upon the same general plan; yet it would be palpably unsafe to found conclusions as to the relations of the respective builders, upon the narrow basis of these resemblances alone.

USE OF COPPER AND SILVER BY THE AMERICAN ABORIGINES.*

In the paragraphs relating to St. Lawrence county, mention is made of a singular aboriginal deposite of burial, on the Canadian shore of the St. Lawrence River, near Brockville. Here were found a number of skeletons and a variety of relics, among which were a number of copper implements. They were buried fourteen feet below the surface of the ground. Two of the copper articles were clearly designed as spear-heads; they were pointed, double-edged, and originally capable of some service. One was a foot in length. A couple of copper knives accompanied these, and also an implement which seems to have been designed as a gouge.† Some implements entirely corresponding with these have been found in Isle Royal, and at other places in and around

* Pages, 176–188. † Ancient Monuments of Mississippi Valley, p. 201.

Lake Superior. Whether or not these are relics of the existing Indian tribes, it is not undertaken to say, although it seems highly probable that they are. That the Indians of New England, New York, and Virginia, to a limited extent, possessed copper ornaments and implements at the time of the discovery, is undoubted; but it is not to be supposed for an instant that they obtained it by smelting from the ores. They unquestionably procured it from the now well known native deposits around Lake Superior.

Raleigh observed copper ornaments among the Indians on the coast of the Carolinas; and Verazzano mentions articles, probably ornamental, of wrought copper, among the natives which he visited in a higher latitude, "which were more esteemed than gold." Granville speaks of copper among the Indians of Virginia, which were said to have been obtained among the *Chawanooks* (Shawanoes?). "It was of the color of our copper, but softer." He endeavored to visit the place where it was represented to be found; but after a toilsome journey of some days into the interior, the search was abandoned. This was a grievous disappointment at that time, when the minds of men were filled with visions of vast mineral wealth, and when the value of the New World was thought to consist in its mines. Granville thus concludes his account of his fruitless expedition: "I have set down this voyage somewhat particularly, to the end that it may appear unto you (as true it is) that there wanted no good will, from the first to the last of us, to have perfected the discovery of this mine; for that the discovery of a good mine, by the goodness of God, or a passage to the South Sea, or some way to it, and nothing else, can bring our country in request to be inhabited by our people."* Heriot says, "In two towns 150 miles from the main, are found divers small plates of copper, that are made, we are told by the inhabitants, by people who dwell farther in the country, where, they say, are mountains and rivers which yield white grains of metal, which are deemed to be silver. For the confirmation whereof, at the time of our first arrival in the country, I saw two small pieces of silver, grossly beaten, about the weight of a *tester*, [an old coin about the weight of a sixpence sterling,] hanging in the ears of a Wiroance. The aforesaid copper we found to contain silver."† Robert Juet, in his account of Hudson's discovery of the river which bears his name, asserts that the savages "had red copper tobacco pipes, and other things of copper, which they did wear about their necks." He makes mention, in another place, of "yellow copper," as distinct from what he terms "red copper." Both Behring and Kotzebue found copper implements in use among the Indians of the Northwest Coast.‡ McKenzie mentions copper as

* Granville's Voy., 1585, in Pinkerton, vol. xii, p. 580.
† Heriot's Voy., 1586, in Pink., vol. xii, p. 594.
‡ Behring's First Voy., p. 85; Kotzebue, Voy., vol. i, p. 227.

being in common use among some of the extreme Northern tribes, on the borders of the Arctic Sea. "They point their arrows and spears with it, and work it up into personal ornaments, such as collars, ear-rings, and bracelets, which they wear on their wrists, arms, and legs. They have it in great abundance, and hold it in high estimation."* Owing to the difficulty of reducing iron from the ore, an acquaintance with that metal has usually been preceded by a knowledge of copper, silver, and gold. "These three metals," says Robertson, "are found in their perfect state in the clefts of rocks, in the sides of mountains, or in the channels of rivers. They were accordingly first known and applied to use. But the gross and stubborn ore of iron, the most serviceable of all metals, and to which man is most indebted, must twice feel the force of fire, and go through two laborious processes, before it becomes fit for use." Says Lucretius:

"Sed prius *æris* erat, quam *ferri* cognitus usus."

It was the difficulty of obtaining iron from the ores, or the possession of the art of so tempering or hardening copper as to make it answer most of the purposes to which steel is now applied, one or both, that perpetuated the use of bronze instruments in Egypt, as well as in Greece and Rome, long after those nations became acquainted with the former metal.

It may be regarded as certain, that the American aborigines, at the period of the discovery, were in ignorance of the uses of iron. It is true Vespuccius mentions a tribe of natives near the mouth of the La Plata, in South America, who possessed iron points to their arrows. It was probably obtained from native masses in that vicinity. The inhabitants of Madagascar obtain a part of their iron from such sources. A late traveller in Chile observes: "It appears that the Indians of Chile had, at the time of their discovery, in some very rare instances, iron blades to their lances; which led to the erroneous supposition that they were so far advanced in metallurgy as to be able to reduce and refine that metal from the ores. Our surprise will cease upon recollecting that this valuable metal already existed naturally in South America, in the very extensive deposits of native iron at *Santiago del Estero*, which has proved to be of meteoric origin, and differing from that at Zacatecas and Durango in Mexico, described by Humboldt, in the absence of earthy matter, and in not being, like them, in round masses, but in a horizontal bed of considerable extent and variable thickness, now for the most part covered with drifting sand, and resting on a bed of the same material."† Copper, on the other hand, seems to have been very

* Second Journey, p. 333.
† Mier's Travels in Chile, etc., vol. ii, p. 464.

abundant, and much used for implements, among all the semi-civilized nations of the continent. Columbus, when at Cape Honduras, was visited by a trading canoe of Indians. Amongst the various articles of merchandise which constituted their cargo, were "small hatchets, made of copper, to hew wood, small bells and plates, crucibles to melt copper, etc."* When the Spaniards first entered the province of Tuspan, they found the Indians in possession of an abundance of copper axes, which, in their greediness, they mistook for gold, and were much mortified on discovering their mistake. "Each Indian," says Bernal Diaz, "had besides his ornaments of gold, a copper axe, which was very highly polished, with the handle curiously carved, as if to serve equally for an ornament as for the field of battle. We first thought these axes were made of an inferior kind of gold; we therefore commenced taking them in exchange, and in the space of two days had collected more than six hundred; with which we were no less rejoiced, as long as we were ignorant of their real value, than the Indians with our glass beads." In the list of articles exacted as an annual tribute from the various departments of the Mexican empire, as represented by the Mexican paintings, were "one hundred and sixty axes of copper" from the southern divisions. * * *

The Peruvians used copper for precisely the same purposes with the Mexicans. Says La Vega, "They make their arms, knives, carpenters' tools, large pins, hammers for their forges, and their mattocks, of copper; for which reason they seek it in preference to gold." And Ulloa adds, "The copper axes of the Peruvians differ very little in shape from ours; and it appears that these were the implements with which they performed most of their works. They are of various shapes and sizes; the edge of some is more circular than others, and some have a concave edge."†

The knowledge of alloying was possessed by both the Mexicans and Peruvians, whereby they were enabled to make instruments of copper of sufficient hardness to answer the purposes for which steel is now deemed essential. Their works in stone and wood, whether in dressing the huge blocks of porphyry composing some of their structures, or in sculpturing the unique statues which are found scattered over the seats of their ancient cities, were carried on entirely with such instruments, or with still ruder ones of obsidian and other hard stones.

The metal used as an alloy was tin; and the various Peruvian articles subjected to an analysis, are found to contain from three to six per cent. of that metal. The chisel analyzed by Humboldt contained copper 94, tin 6.‡ A copper knife found in Peru by J. H. Blake, Esq., of Boston, contained about four per cent. of

* Herrara, vol. i, p. 260. † Vol. i, p. 483. ‡ Res., vol. i, p. 260.

tin. This gentlemen informs me, that "The knives, gravers, and other implements found by myself in Peru, contain from three and a half to four per cent. of tin, which is sufficient to give them a very considerable degree of hardness.* The knives which I send you were found about the person of a mummy which I took from an ancient cemetery near Arico. Various household articles were found with it; but these were the only ones of metal, except a medal of silver suspended around the neck. The chisels or gravers are pointed at one end, with a cutting edge at the broad part. They were found at various places in the northern part of Peru. At the ancient city of Atacama, I found several hoes of copper, shaped very much like the 'grubbing-hoes' to be found in our warehouses." * * *

In 1831, arrow-points were discovered with a skeleton, near Fall River, Massachusetts. With this skeleton were found a corroded plate of brass, supposed to have constituted a breastplate, and a number of rude tubes of the same metal, composing a sort of belt or cincture. The arrow-points are two inches in length, and one and one-third inches broad at the base. This skeleton attracted a good deal of attention at the time, and was supposed to lend some sanction to the then popular theory of the early discovery and settlement of the coast of New England by the Northmen. An analysis of the compound metal of which the relics were composed, was made by Berzelius, under the direction of the Royal Society of Antiquaries of Denmark. The result of the analysis was published by that learned body, in the following comparative table:

	Copper.	Zinc.	Tin.	Lead.	Iron.
Brass from Fall River,	70·29	28·03	0·91	0·74	0·03
Old Danish,	67·13	20·39	9·24	3·39	0·11
Modern Brass,	70·16	27·45	0·79	0·20	——

It will be seen by the table, that the metallic relics found at Fall River bear in their composition a suspicious resemblance to modern brass. They certainly differ widely, in this respect, from any of the alloys of copper found elsewhere on the continent. Without alluding to the rudeness of the workmanship exhibited by the Fall River relics,—a rudeness entirely inconsistent with that stage of advancement indicated by a knowledge of smelting and alloying the metals,—the fact that the skeleton accompanying them was found buried, after the Indian mode, in a sitting posture, and enveloped in bark, places in a very strong light the probability that the burial was made subsequent to the first set-

* The Indians of Chile, previous to the discovery by the Spaniards, made use of a kind of *bronze metal*, found native in the country, which is an alloy of copper, zinc, and antimony, called *campañil* by the Spaniards. From this they formed their cutting instruments.—*Mier's Trav.*, vol. ii, p. 464.

tlement of New England, in 1625, and that the relics were of native manufacture, from sheets or plates of brass obtained from the early colonists. This probability is further sustained by the circumstance that a portion of the wood attached to the arrows was still preserved, as was also a large proportion of the bark envelope of the skeleton, at the time of its discovery; which could hardly be the case, if its interment had been made as early as the tenth century, which is the period assigned to the Scandinavian visits. It cannot be claimed that the preservative properties of the salts of the copper could have more than a very local application or influence.

And while upon this point, it may be mentioned that Wood, in his "New England Prospect," published in 1634, (p. 90,) distinctly states that the Indians obtained brass of the English for their ornaments and arrow-heads, the last of which, he adds, "*they cut in the shape of a heart and triangle, and fastened in a slender piece of wood, six or eight inches long*"—in a manner, according to the description, precisely similar to that observed in the articles found with the Fall River skeleton. If any further evidence were needed to establish the opinions already advanced, it might be found in the fact that, a few years ago, in the town of Medford, near Boston, in Massachusetts, a skeleton was exhumed, accompanying which were found some flint arrow-heads, and some brass arrow-points, *identical* with those discovered at Fall River, together with a *knife of English manufacture* of two hundred years ago.

It has already been suggested that the shore of Lake Superior is the probable locality whence the copper used by the aborigines of, at least, the Eastern and Middle States, was obtained. This suggestion is rendered more than probable by the fact that abundant traces of aboriginal mining have been discovered there in the course of recent explorations. Some of the more productive veins in the "Copper Region" seem to have been anciently worked to a considerable extent. The vein belonging to the "Minnesota Company" exhibits evidence of having been worked for a distance of two miles. The ancient operations are indicated by depressions or open cuts on the course of the vein. Upon excavating these, ample proofs of their artificial origin are discovered, consisting of broken implements of various kinds, stone axes, hammers, etc. Traces of fire are also frequent. Some of the excavations are found to have extended to the depth of thirty feet. In the mine of the particular company above named, covered by fifteen feet of accumulated soil, and beneath trees not less than four hundred years old, was found a mass of pure copper, weighing 11,537 lbs., from which every particle of the rock had been removed. It had been supported by *skids* and was surrounded by traces of the fire which had probably been

used to disengage the rock. Here, too, were found various rude implements of copper.

At the Copper Falls and Eagle River, as at the Vulcan and other mines, the ancient shafts are frequently discovered. Professor W. W. Mather, the eminent geologist, in a private letter, referring to the two mines first named, says: "On a hill, south of the Copper Falls Mine, is an excavation, several feet in depth and several rods in length, extending along the course of the river. Fragments of rock, etc., thrown out of the excavation, are piled up along its sides, the whole covered with soil, and overgrown with bushes and trees. On removing the accumulations from the excavation, stone axes of large size, made of greenstone, and shaped to receive withe handles, are found. Some large round green-stone masses, that had apparently been used for sledges, were also found. They had round holes bored in them to the depth of several inches, which seem to have been designed for wooden plugs, to which withe handles might be attached, so that several men could swing them with sufficient force to break the rock and the projecting masses of copper. Some of them were broken, and some of the projecting ends of rock exhibited marks of having been battered in the manner here suggested."

The great Ontonagon mass of virgin copper, now deposited at Washington, when found, exhibited marks of having had considerable portions cut from it; and the ground around it was strewed with fragments of stone axes, which had been broken in endeavors to detach portions of the mass. It is not impossible that this mass was one of those which had been brought to the surface by the ancient miners.* The questions naturally arise, By whom were these ancient mining operations carried on? and to what era may they be referred? Without noticing the improbable suggestion, that the various excavations which have been discovered are due to the French, (who, it is well known,

* Since the above was written, the subjoined additional facts have been published in the Lake Superior Journal newspaper, of the date of September 25, 1850:

"We have been shown by Charles Whittlesey, Esq., of the Ontonagon Mine, a copper arrow-head, and a piece of human skull and other bones, which have lately been found in the ancient Indian excavations on the Ontonagon River. The arrow-head is now about two inches in length, and seems to have had originally a socket, though but part of it remains. Several chisels, or instruments resembling chisels, having sockets like the common carpenter's chisel, and small gads or wedges, have also been found at the Minnesota Mine.

"But the greatest curiosity we have seen in the way of these articles is a stick of oak timber lately taken out of one of the ancient 'pits,' or shafts, at the Minnesota Mine, twenty-seven feet below the surface. It is a small tree, about ten feet in length, and eight or ten inches in diameter, having short limbs two feet apart, and at nearly right angles with one another; and on this account, and from its standing nearly upright, it is supposed to have been used as a ladder by the ancient miners. In this shaft, and around and over this stick, were rocks and earth, and large trees were growing over it. Many centuries must have elapsed since that ancient ladder was placed there."

were early acquainted with the mineral riches of the Northwest,) we may find a satisfactory answer to the first of these questions, if not to the last, in the character of the deposits which recent explorations have disclosed from the mounds of the West. Among the multitude of relics of art found buried upon the ancient altars, or beside the bones of the dead, articles of copper are of common occurrence. It is sometimes found in native masses, but generally worked into articles of use or ornament. I have taken from the mounds, axes, well wrought from single pieces, weighing upwards of two pounds each. They are symmetrical, corresponding very nearly in shape with the Mexican and Peruvian axes. Some are double-bladed, others *gouge-shaped*, and evidently designed to be used as adzes. Besides these, chisels, graving tools, and a great variety of ornaments, bracelets, gorgets, beads, etc., etc., composed of this metal, have been discovered. Some of the ornaments are covered with silver, beaten to great thinness, and so closely *wrapped around* the copper that many persons have supposed that the ancient people understood the difficult art of plating.

Some years ago, a mass of native copper, weighing upwards of twenty pounds, was found upon the banks of the Scioto River, near Chilicothe, in Ohio. Large portions had evidently been cut from it. The discovery of these native masses, not to mention the amount of manufactured copper, implying a large original supply, points pretty certainly to the shores of Lake Superior as the locality whence the metal was obtained. There are other circumstances, still more conclusive, and which, taken into connection with the traces of ancient mining in the mineral region, leave no room to doubt that the race of the mounds obtained their supplies of copper from that direction. It is well known that while some of the Lake Superior copper is almost perfectly pure, a part is alloyed with silver in various proportions, and some is found having crystals of silver attached to it,—a peculiar *mechanico-chemical combination*, known to exist nowhere except in this region. This characteristic combination has been observed in some of the specimens, both worked and unworked, found in the mounds, and enables us to identify fully their primitive locality. The great industry and skill which the mound-builders displayed in the numerous and often gigantic monuments which they have left us at the West, warrant us in ascribing the ancient excavations, etc., in the mineral region to them. The Indian hunter is proverbially averse to labor; and we have no instance of the Indians undertaking works of this extent. Still, it cannot be doubted that they also obtained copper from this region. Indeed, we have direct evidence of the fact; but it is probable that they procured it only in small quantities, when it was found exposed at the surface, or on the banks of streams. Alexander

Henry, who penetrated to Lake Superior at the period of the second French war, assures us that the Indians obtained copper here, which they "made into bracelets, spoons," etc.* As we have seen, the early explorers on the coasts of New England, New York, Virginia, the Carolinas, and Florida, among whom we may mention Hudson, Verrazano, Raleigh, Heriot, Ribaude, De Soto, all concur in saying that the Indians had copper in small quantities among them, which they worked into pipes and ornaments. De Soto found copper hatchets among some of the tribes along the Gulf, which they professed to have obtained from "a province called *Chisca*, far toward the North."

All the copper found in the mounds appears to have been worked in a cold state; and although the axes and other instruments appear to be harder than the copper of commerce, they have been found, upon analysis, to be destitute of alloy. The superior hardness which they possess over the unworked metal, is doubtless due to the *hammering* to which they have been subjected. Some of the sculptures in porphyry, and other hard stones found in the mounds, exhibit traces of having been *cut;* but as they now turn the edge of the best tempered knife, we are at a loss to conjecture how they were so elaborately and delicately worked. The lack of cutting implements, among most rude people, is partially met by various contrivances, the most common of which is attrition, or rubbing or grinding on hard stones. It was thus the stone axes, etc., of the early Indians were slowly and laboriously brought into shape. It however needs but a single glance at the mound sculptures to convince the observer that such rude means are wholly inadequate to the production of works possessing so much delicacy of execution.

The Mexicans and Peruvians were wholly unacquainted with the use of iron; and their carvings, etc., were all wrought with copper tools. They, however, contrived to harden them with an alloy of from three to seven per cent. of tin. I have some of their implements in my possession, which answer a very good cutting purpose. It nevertheless seems incomprehensible how their extensive works in granite, porphyry, and other obstinate materials, could be carried on with such aids. The Egyptians, although not ignorant of iron, were compelled, by a variety of circumstances, to use copper tools, and with these most of their gigantic labors were effected. They must of necessity have had some means of hardening the metals; yet it is a singular fact, that, with the exception of a few bronze weapons of probably a comparatively late date, the chisels and other implements found in the monuments and at the quarries are *pure copper.*

Use of Silver by the American Aborigines.—Granville, as we have seen in the quotation from his voyage on page 177, speaks

* Travels, p. 195.

of finding pieces of silver amongst the Virginia Indians, "grossly beaten," and used for purposes of ornament. Having shown that the copper found amongst the Indian tribes of the north was probably obtained from the native deposits around Lake Superior, we have little difficulty in accounting for the presence among them of small quantities of silver, derived from the same locality, where it also exists in a native form. That the silver in use amongst the mound-builders was principally if not wholly obtained there, seems incontestible. In no instance does it appear to have been smelted.

A variety of silver ornaments were discovered some years ago in one of the mounds at Marietta, Ohio, under very singular circumstances, and in a remarkable connection. The circumstances have been detailed by the accurate pen of Dr. S. P. Hildreth, in a communication to the President of the American Antiquarian Society, dated "Marietta, Nov. 3, 1819."

"In removing the earth composing an ancient mound in the streets of Marietta, on the margin of the plain, near the fortifications, several curious articles were discovered. They appear to have been buried with the body of the person to whose memory the mound was erected.

"Lying immediately over, or on the forehead of the body, were found three large circular bosses, or ornaments for a sword-belt or a buckler: they are composed of copper overlaid with a thick plate of silver. The fronts are slightly convex, with a depression like a cup in the centre, and measure two inches and a quarter across the face of each. On the back side, opposite the depressed portion, is a copper rivet or nail, around which are two separate plates, by which they were fastened to the leather. Two small pieces of the leather were found lying between the plates of one of these bosses; they resemble the skin of a mummy, and seem to have been preserved by the salts of copper. The copper plates are nearly reduced to an oxyd, or rust. The silver looks quite black, but is not much corroded, and in rubbing is quite brilliant. Two of these are yet entire; the third one is so much wasted that it dropped in pieces in removing it from the earth. Around the rivets of one of them is a small quantity of flax or hemp, in a tolerable state of preservation. Near the side of the body was found a plate of silver, which appears to have been the upper part of a sword-scabbard; it is six inches in length and two inches in breadth, and weighs one ounce. It has no ornaments or figures, but has three longitudinal ridges, which probably corresponded with the edges or ridges of the sword; it seems to have been fastened to the scabbard by three or four rivets, the holes of which remain in the silver.

"Two or three broken pieces of a copper tube were also found, *filled with iron rust.* These pieces, from their appearance, composed the lower end of the scabbard, near the point of the sword. No signs of a sword itself were discovered, except the appearance of rust above mentioned. Near the feet was found a piece of copper weighing three ounces [now in the Museum of the Antiquarian Society of Worcester]. From its shape it appears to have been used as a *plumb*, or for an or-

nament, as near one of the ends is a circular crease or groove, for tying a thread: it is round, two inches and a half in length, one inch in diameter at the centre, and half an inch at each end. It is composed of small pieces of native copper pounded together; and in the cracks between the pieces are stuck several pieces of silver, one nearly the size of a half-dime. A piece of red ochre or paint, and a piece of iron ore [*hematite*] which had the appearance of having been partially vitrified [*polished?*], were also found.

"The body of the person here buried was laid upon the surface of the ground, with the face upwards, and his feet pointing to the south-west. From the appearance of several pieces of charcoal and bits of partially burned fossil coal, and the black color of the earth, it would seem that the funeral obsequies had been celebrated by fire; and while the ashes were yet hot and smoking, a circle of these flat stones had been laid around and over the body. The circular covering was about eight feet in diameter; and the stones yet look black, as if stained by fire and smoke. This circle of stones seems to have been the nucleus over which the mound was formed, as immediately over them is heaped the common earth of the adjacent plain. At the time of opening it, the height was six feet, the diameter between thirty and forty. It has every appearance of being as old as any in the neighborhood, and was, at the settlement of Marietta, covered with large trees. It seems to have been made for this single personage, as the remains of one skeleton only were discovered. The bones were much decayed, and many of them crumbled to dust on exposure to the air."

The silver-plated discs and also the embossed silver plate supposed by Dr. Hildreth to have been a sword ornament, have been critically examined, and it is beyond doubt that the copper "bosses" are absolutely *plated*, not simply overlaid, *with silver*. Between the copper and the silver exists a connection, such as, it seems to me, could only be produced by heat; and if it is admitted that these are genuine remains of the mound-builders, it must, at the same time, be admitted that they possessed the difficult art of plating one metal upon another. There is but one alternative, viz., that they had occasional or constant intercourse with a people advanced in the arts, from whom these articles were obtained.

ART. XXXIV.—*On the corrosion of an Alloy, composed of Copper and Silver, in Sea-water;* by AUG. A. HAYES, Assayer to the State of Massachusetts.

SOME analyses I made many years since of sheathing copper, which had long resisted the action of sea-water, proved the presence of nearly one ten-thousandth part of silver. It was found that even this small portion of silver, sensibly modified the chemical relations of the metal, and observations had indicated that the quality for sheathing, was improved.

Copper of this kind, is frequently met with in commerce and is derived from the Chilian ores of copper, which although argentiferous, do not yield enough silver, to render its separation economical.

An occasion offered for again examining this subject, when the argentiferous native copper of Lake Superior was first refined and rolled by the Revere Copper Company, more than five years since, and the results have lately been obtained.

Four suits of sheathing, for large merchant vessels, formed the subjects for observations, the metal being of uniform composition, as determined by assay of the clipping from many sheets. Two thousand parts of the alloy contained 4 parts of pure silver, or the standard ton of this country contained 4 lbs. of silver.

A *proximate* analysis of this metal was also made, and it proved to be pure copper, throughout the mass of which, an alloy of silver and copper was evenly distributed, so as to form either a mixture, or a compound alloy, in which one part of the copper is truly combined with the silver and the other larger part, simply combines with the alloy. This is a very common constitution of alloys, in which two metals exist, without any metalloid occurring to disturb the simplicity of the union and always indicates, a careful purification of the metals.

It was assumed as probable, that the silver alloy would close the pores of the copper which takes place with a tin alloy in bronze and in a mechanical way, confers durability. If however, corrosion should take place, it was in accordance with observed cases that the silver alloy would act as a negative element, and the copper alone would be removed. How erroneous these inferences proved, will be seen in the detail of the results.

The "Chicora" was coppered Jan. 9, 1847, taking 7,392 lbs. metal, which was fastened by bronze nails. She was employed in trade to China and wore her copper so rapidly, that it was removed in March, 1849, 2,628 lbs. only remaining. In this case the sheets after the usual operations, had been consolidated by "cold rolling."

The "Serampore" was coppered January 18, 1847, requiring 8,447 lbs. of "cold rolled" metal, secured by bronze nails. She sailed to China and home, *via* Cape of Good Hope, and to the Pacific and home, *via* Cape Horn, requiring new copper in March, 1850. The weight of the remaining copper, was not ascertained.

The "Hamilton" was coppered October 22, 1847, requiring 7,706 lbs. metal, secured by bronze nails. The sheets used were in the ordinary or annealed state. This vessel was employed in the India trade and wore out her copper in August, 1849. The weight of the copper remaining was 3,086 lbs.

The "Carthage" was coppered November 26, 1847, requiring 8,727 lbs. "cold rolled" metal fastened by bronze nails. She

was employed in the India trade and her sheathing was destroyed in August 1849. The copper remaining, weighed 5,810 lbs.

Omitting the case of the "Serampore" where the corrosion cannot be determined by weight, we have the loss in every one hundred parts of metal, for the time of duration,—thus,

The "Chicora,"	twenty-seven months,	lost	64·45	per 100
"Hamilton,"	twenty-three "	"	59·95	" "
"Carthage,"	twenty-one "	"	33·45	" "

Allowing the same rate of corrosion and taking the time as twenty-seven months for each,

The "Chicora" lost	- -	64·45 in 100
"Hamilton"	- - -	70·38 " "
"Carthage,"	- - -	43·00 " "

In the cases of the "Hamilton" and "Carthage," we perceive the influence of the different processes of manufacturing the sheets, on the durability of the copper. By the operation of "cold rolling," the surfaces of the sheets are rendered very compact, and in any corroding solution, they bear a negative relation to the metal in the same sheets, between these surfaces. Such copper is also always strongly negative to annealed copper in acid solutions, until the hardened surfaces are removed, it then loses this relation. The "Hamilton" exhibits the greatest effect of sea-water action on the annealed alloy, while in the Carthage, the protecting influence of the hardening surface, was exerted nearly to the time her copper was removed.

These observations establish the fact of the rapid corrosion of an alloy thus constituted, and show its entire unfitness for sheathing purposes.

The average duration of copper sheathing decreases slightly, as the requirement of greater speed in sailing is more urgent. Taking one hundred merchant ships, sailing on different oceans, the average duration now on American ships, is three years.

On the point of the *kind* of corrosion, following the exposure of the alloy to sea-water and air, the information obtained in these trials, is of a definite character. Part of the sheets remaining and an ingot of the copper from smelting a large quantity, were assayed and the results showed that, the same proportion only of silver remained, as was originally contained in the alloy. The silver alloy therefore, by taking the negative state in the mass of the metal, hastened its destruction, while its own form and condition were such, that it separated as the copper, was corroded.

For the records of facts and much assistance continued for years, in connection with the subject of copper corrosion, I am indebted to the kindness of my friend, Mr. J. Davis, Jr., Treasurer of the Revere Copper Company.

1 Pine st., Boston, January 30, 1851.

Art. XXXV.—*On the Calculus of Operations;* by John Paterson, A.M.*

In the algebraical and other forms of calculus in vogue, the various quantities, numbers, symbols, functions, etc., constituting the matter of the science, are understood as ratios of *magnitudes* merely as such. The expressions x, x^2, x^3, for example, are ratios of the magnitudes $x1$, $x^2.1^2$, $x^3.1^3$, to the unit magnitudes 1, 1^2, 1^3, respectively; the units 1, 1^2, 1^3, representing a line, a square surface, and a cubical volume respectively. But as all geometrical magnitude is confined to one, two, or three dimensions, it follows, that while such expressions as x^4, x^5, etc. are ratios of $x^4\,1^4$, $x^5\,1^5$, etc. to 1^4, 1^5, etc., these units of comparison can no longer represent geometrical magnitudes. The question arises, what do these units signify? They are complex units of number. But, we ask, numbers, or number of what? Wherein does 1^4, 1^5, etc., differ from 1? *Number* is a general idea, and therefore must be applicable to several particular instances. If then a particular instance of geometrical unity can be found, to which all other powers and roots of unity can be referred as a base, we shall be prepared to answer the preceding question. The Calculus of Operations professes to have discovered such base, and to have broached the method and traced the route which leads to the most general interpretation of the functions of unity. By this calculus, all functions are regarded as ratios of the measures of operations performed in space and time; for example, the expression x^4 is the ratio obtained by comparing the operation whose measure is $x^4\,1^4$, with that whose measure is 1^4; the latter being a compound unit of operation, ultimately referable to a simple unit of space, a linear unit.

Addition is an operation, in which we take for unit measure of operation the distance through which the *added* body is transfered in the unit of time; each unit of the recorded result expressing the performance of *one* operation of addition, and indicated geometrically by the unit of length drawn to the *right* of an origin.

Subtraction is an operation diametrically opposed to that of addition, and will therefore be indicated geometrically by the unit of length (measure of operation) drawn to the *left* of an origin.

Multiplication is an abridged method of performing a series of additions; so that when the multiplier is unity, the operation coincides with the performance of one addition. Consequently

* This article was received by the editors along with the recent work of Mr. Paterson, entitled, "The Calculus of Operations." 184 pp., with 4 plates. Albany, 1850—Gray and Sprague. The merit and peculiar views of the work will be gathered from this exposition of the subject by the author.

successive multiplications by unity, or the involution of a geometrical unit, will be geometrically interpreted by so many successive productions of the linear unit to the right of the origin. This informs us that the nth power of a linear unit is a line of n times the length of the line involved, or that $1^4=4.1$ by this method. But if, instead of a linear unit, we take for a geometrical multiplier the nth part of the circumference of a circle to radius unity, the performance of n successive multiplications will transfer the *multiplied* body (multiplicand) around the circumference, by n successive steps, to its point of departure; at which point it had the measure unity (the radius of the circle), and therefore we now have $1^n=1$, or the powers of geometrical and arithmetical unity may be made to coincide. Inversely, if the entire circumference be taken for geometrical unit, its nth part will represent the nth root of unity. The discussion of the two cases in which n is equal to 2 and to 4, furnishes a complete logical demonstration of the properties of the four algebraical signs; for which, see the second and last chapters of the Calculus of Operations. In all cases the distances traversed have a dynamical value, as measures of the respective operations of describing them.

Division is an operation compounded of addition and subtraction; wherein the quotient, which is a pure ratio, is retained as the measure of the result of the operation, which consists in effecting an equilibrium between the forces of which the dividend and divisor are the measures.

In the fluxionary calculus, the various functions or complex ratios are treated by the analyst as though they were primitive existences, or productions furnished by the hand of nature. Just as the chemist collects his specimens of mineral substances from the bowels of the earth, and proceeds to decompose and analyze them by the application of fire; so the analyst takes his given functions, and proceeds to analyze them by differentiation after the method of Leibnitz, or by derivation according to Lagrange. The calculus of operations, on the contrary, proceeds synthetically, and actually shows how to construct the ratio, or how the function may be generated, and thereby furnishes an irrefragable demonstration of its constitution. The theory of generating powers comes in for a large share in the operations of general algebra, and has an ample bearing upon our views of the philosophy of nature. By this theory alone, unaided by and uninterfering with the notion either of infinitesimals or of limits (except so far as merely to show their necessity for the production of certain particular classes of phenomena), the theorem of Taylor, which is the acknowledged basis of all mathematical development, is directly established in its most general form, and the analogy between symbols of operation and of quantity receives its fullest generalization. Lagrange's theory of derivation shows

how, when the primitive function is given, all the successive derivatives are to be obtained from it; but the theory of generation evolves the primitive, together with its derivatives, all by one same process.

Generation is still an *operation*, but characteristically distinguished by its result, which is, in general, itself a *generator*, or an *operator* of an order or rank next inferior to that of its own generator.

A constant velocity causes a body, or material unit, to describe a distance which increases uniformly, or as the time; and will therefore generate the distance unity (linear unit) in the unit of time, and consequently the distance whose ratio is x in x units of time. A constant velocity, therefore, has but one measure of operation, namely the unit of distance, and thus corresponds exactly with multiplication by linear unity.

A constant force generates velocity uniformly; and this velocity, from the very commencement of its existence, operates upon the material unit, and causes it to describe the unit of distance in the first unit of time. But at the expiration of this first unit of time, the amount of velocity, having increased uniformly during that time, is evidently such as will of itself cause the material unit to describe *twice* the distance in the immediately succeeding unit of time, that was described by it in the preceding unit of time; that is, the velocity generated in the unit of time has *two* units of distance for its measure in the succeeding unit of time, and *one* unit of distance for its measure in the unit of time during which it was itself generated by the constant force. Or we may say also, that the constant force has at once *two* measures of operation: first, an *immediate* measure, the velocity *two*, generated in the unit of time; and, secondly, the *mediate* measure *one*, being the distance generated by the velocity during its own generation. Since the *two* units of velocity were *uniformly* generated in the unit of time, it follows that exactly *one* of these velocities was generated in each semiunit of time; that is to say, the constant force performs *one operation* in the semiunit of time; or, in general, a semiunit of time is the interval occupied in the performance of *one* genetic operation, in which the result itself is a generator. From these considerations, we readily find that the velocity increases as the duplicate of the time, and the distance as the square of the time; and we have now discovered a method which enables us to raise the dimensions of a ratio x.

Assume a series of subordinated generating forces, or more generally a hierarchy of generating powers, such that the power of the lowest order shall correspond to a constant velocity, which generates distance (power of the order zero) uniformly; the power of the second order shall correspond to a constant force, which generates velocity uniformly; the power of the third or-

der, which generates power of the second order uniformly; the power of the fourth order, which generates power of the third order uniformly, etc., etc.

By deduction it is found, in the case of the power of the third order, which performs *two* genetic operations in the unit (one in each semiunit) of time, thereby generating two units of power of the second order, that the two generated powers of the second order together perform three genetic operations in the first unit of time, thus generating three powers of the first order; which three powers, during their own genesis generate the power zero, or unit measure of operation or distance. And from these considerations we find that the generated power of the second order increases as the duplicate of the time, the velocity increases as the triple square of the time, and the distance as the cube of the time.

The power of the fourth order performs two operations, or generates two powers of the third order in the first unit of time; which two powers of the third order together perform three operations, or generate three powers of the second order in the same unit of time; which three powers of the second order together perform four operations, or generate four powers of the first order in the unit of time; and finally the four powers of the first order generate the power of the order zero, or unit of operation or distance in the first unit of time. Each generated power, after its generation, becomes in its turn a primitive generator, and generates its proper hierarchy of powers; and when the measures of their several results are reduced in the proportion of those of the independent primitive generator, they yield the several terms of the fourth power of a binomial. We find that the generated power of the third order increases as the duplicate of the time, the power of the second order increases as the triple square of the time, the velocity increases as the quadruple cube of the time, and the distance increases as the biquadrate of the time.

These examples are sufficient to show that the process may be extended to any required positive number n; and thus when the operations performed are genetical, our calculus shows the direct genesis of any positive power of any given number x; while we have seen that when the operations were performed by a power of the first order, they corresponded to successive multiplications, and served merely to determine the powers of a geometrical unit. Now when the successive multiplications are effected by semi-revolutions around a centre or origin of measurement, we exhibit the successive powers of negative unity; and similarly by combining the principle of revolution with our genetical operations, we are enabled to show the genesis of negative and fractional powers of x. Other conditions are readily assigned, which determine the several forms of exponential series, together with their trigonometrical and logarithmical relations.

The entire structure of the Calculus of Operations is based upon the principle of *uniformity of action*. Under this principle, when the order of the primitive operator is higher than unity, the final result will be a corresponding power of the general number x; but when the operator is of the first order only, we get powers of unity.

It is conceived that a uniform action is susceptible of accurate measurement in its immediate result, which must necessarily increase uniformly in time; and when this result is also an *actor*, the rate at which its *effect* increases is to be deduced in conformity with the first principles of uniform action of the primitive actor, and is to be expressed in time and number of operations, which are ultimately referred to space in the final result.

The dimension of the simplest form of extent can only be determined by means of an operation, to wit, the operation of measurement. Time, which itself is no *magnitude*, is yet susceptible of measurement in space; and the operation of effecting this measurement involves an expenditure of force, the measure of which is precisely equivalent to, or identical with, that of the time which it records. And so of all magnitudes whatever, their measure implicitly contains the measure of the force expended in effecting their measurement, which may be taken cognizance of for the purpose of furthering the progress of calculation; and conversely, all operations, addition, subtraction, multiplication, etc., have their measure in space and time. These measures have generally been overlooked in analytical operations; but by recognizing and restoring them to their legitimate place on our tablets, we fill up the hiatus which otherwise exists between the *mise en equation* and the final answer.

The principle of uniformity of action, it is believed, will be found to hold a place in algebraical logic, similar to that held by the celebrated *dictum de omni et nullo* in the logic of Aristotle. It is believed, also, that the preliminary scheme of classification comprises the categories of existence complete; that these categories are not merely subjective, like those of the system of Kant, but have full objective validity; and that they are not liable to the charge either of deficiency or redundancy, as are the famed categories of Aristotle.

It is to be recollected that this is the first publication of the discoverer of this method (if peradventure it shall be admitted to the title of *a method*), and that it is given in the form of researches merely, which only point to the definitive form of the calculus. As an instance of its fertility in analogy and interpretation, it may be remarked, that in ordinary multiplication, the linear unit (unit of operation) is constant, and successive multiplication merely increases the dimensions of x, as $1, x, x^2, x^3$, etc. But when it is shown how the unit of operation may in-

crease with the time x, we obtain the series 1, $1x$, $2x^2$, $3x^3$, etc., wherein appears the leading numerical factor concerned in the process of differentiation: or if the unit of operation be negative, the series becomes 1, $-1x$, $+2x^2$, $-3x^3$, + etc., corresponding to the differentials of a negative function: and finally when the unit of operation is circulative, we enter upon the differentiation of exponential functions. Nature, in the case of a body falling in a vacuum under the influence of the force of gravitation, actually develops the function $(x+h)^2$; and it is the intention of the Calculus of Operations to exhibit the harmony which subsists between the objective and subjective, between the phenomena of the external world, and the mental processes which investigate and record them.

ART. XXXVI.—*On the Mammoth Cave of Kentucky;* by Prof. B. SILLIMAN, Jr. (From a letter addressed to Prof. Guyot, Cambridge; dated Louisville, November 8, 1850.*)

I HAVE lately had an opportunity of visiting the Mammoth Cave of Kentucky and have made in connection with Mr. R. N. Mantell a collection of the animals found there, which we propose to send to our much valued friend, Prof. Agassiz, by an early opportunity. My object in writing to you is to say a word regarding the general topographical features of the country and some other matters which I suppose will interest you.

At the level of the Ohio below the falls on which the city stands, are found the lower beds of silurian rocks and upper Devonian, the oldest palæozoic rocks to be seen in all this region. This city is placed on a plateau elevated some seventy-five feet above the low-water mark of the Ohio, and the plain on which it stands represents the general level of the surrounding country for a long distance above and below. Mammoth Cave lies in a direction nearly south of Louisville on the Green river and on the direct road to Nashville, midway between Louisville and the latter city. Leaving Louisville, the stage road follows the main course of the Ohio and generally along its banks to the Salt river, some twenty miles; crossing this river the road bears south, leaving the Ohio on the right, and soon enters a new region. By a gentle and easy ascent you continue to rise for several miles by a circuitous path, passing in succession all the members of the si-

[* The following letter was written with no intention of its being published and only for the gratification of a friend, who has since urged its publication. It is therefore given exactly as it was first written, which may, I trust, be deemed a sufficient apology for whatever want of fullness of detail attaches to a general and rapid sketch.—B. S., Jr.]

lurian and the lower secondary or the mountain limestone until at an elevation of 300 to 400 feet above the Ohio you reach the great upper plateau which stretches away for a long distance, interrupted only by the deep river beds, which are all very nearly on the same level with the Ohio. These upper plains are called the '*Barrens*,' from the general sterility of the soil, which is formed to a considerable extent of stiff red clays and unproductive sands, or of lime rocks lying near the surface. Everywhere in this upper country we are struck with the frequent occurrence of those circular holes or shallow pans which are called 'sinks,' from the popular belief that the surface has fallen away or sunk at some recent period. You see large trees standing dead in the water which fills these hollows, in a situation where of course they could not have grown supposing the water had long occupied its present place. Hence the idea so generally accepted that the surface of the earth has fallen downward, and this is attributed to the wearing away of the rocks beneath by subterranean rivers or by some other mode of aqueous action. It is probable that the hollows, already existing, are made water-tight by the cementing of the surface by fine mud floated by rains from the adjacent roads. I saw hollows of this sort standing full of water in this very dry season, in which the trees were not quite dead, while in others only the denuded trunks were seen. From these stagnant pools arise the poisonous miasms that produce the fevers which are peculiarly abundant in those parts of the Barrens where the sinks are most numerous. It is remarked that the 'sinks' have greatly increased in number, and the miasms in virulence, since the country was opened by cultivation and by roads. These causes have obviously operated to furnish the slime which the rains have washed down into the circular hollows adjacent these improvements, thus rendering them water-tight.

The stage-road to Nashville runs over this upper plateau all the way from Salt river with unimportant exceptions in the valleys of small rivers, until it reaches the valley of the Cumberland river, over one hundred and fifty miles. Within some ten or fifteen miles of Nashville the traveller again descends by a similar gradual declivity full 350 feet to the banks of the Cumberland river, on which the city of Nashville stands. Here again the observer detects the oldest silurian rocks, compact blue crystalline limestones in which the fossils are almost obsolete, and unfossiliferous sandstones, alternating with them.

The Mammoth Cave of Kentucky is situated in the midst of the great upper plain and descends from the uppermost rocks to those which are nearly or quite on a level with the Ohio. Dr. John Locke of Cincinnati has measured the depth of the cave barometrically, and is said to have determined it to be 325 feet

below the hotel, and the level of the rivers of the cave to be the same as that of Green river with which the subterranean rivers or lakes rise and fall in times of flood; so that there is no doubt of a connection existing between Green river and these curious subterranean pools over which the explorer passes in mysterious silence many miles from the entrance, and at least 300 feet from the upper surface. Unfortunately our party was unprovided with barometers, and the measurement of Dr. Locke remains therefore as the only evidence we have of the relative levels of these subterranean waters and Green river.

One atmospheric phenomenon attracted our attention and tasked our ingenuity for a satisfactory explanation. I will mention the fact and our solution of it. If the external air has a temperature above 60° F., the observer, on approaching the mouth of the cave, is met by a blast of cool air blowing outward from the mouth; and if the external temperature is high, say 90° F., the blast amounts to a gale. It is almost impossible, indeed, where the difference of temperature, either way, is considerable, to make the entrance of the cave with a lighted lamp; unless carried with an experienced hand it is surely extinguished. In hot weather, this contrast of temperature and its accompanying blast of air, are at first quite overpowering and you feel as if immersed in a cold bath.

If the air without has a temperature of 59°–60° no current is observed and the flame of a lamp held in a favorable position indicates none. It immediately occurred to me that there must be two currents, one above of warmer air, passing inward, and one below of colder air passing outward, and the reverse, but experiment soon satisfied me that this was not the case. Only one current could be discovered, and on inquiry of the very intelligent guide, 'Stephen,' who is well known for his remarkable powers to all who have been at the cave, I found that this phenomenon had attracted his attention, and that he was satisfied from many observations that only one current existed and that this flowed *out* when the external air was above 60° and *inward* when this was below 60°. Going in, one day at noon, we found the outward blast very strong: we prolonged our stay until past midnight; meanwhile a storm of rain accompanied by lightning had come up, and at 3 A. M. when we again emerged, the temperature outside had fallen to 50°, and the inward gale blew so strongly as to extinguish our lights several hundred yards from the mouth. In fact the guide told us, when more than two miles in the cave, that a change had taken place in the outer air, and that we should probably find a storm raging without. His accustomed senses detected the gentle current inward which we did not notice at so great a distance, and he perceived, as he afterward told us, a change of level in the subterranean rivers since

our crossing them in the morning—the rain which had fallen copiously having already affected them.

I was at a loss for a little time to account for these currents of air, but the following explanation suggested itself. The mouth of the cave is the only communication between the external air and the vast labyrinth of galleries and avenues which stretch away for many miles in the solid limestone. The extent of these underground valleys of denudation, or rather 'excavations,' is vastly greater than I had imagined before going there; branching, crossing, inosculating in all directions, and at all levels, the mind is lost in amazement at their vast proportions, the various beauty which they possess, and at the continuity of the cause which has formed them. The air which they contain is pure and exhilarating. The nitre beds which are of incredible extent in these galleries probably account in part for the purity of the air, as the nitrogen which is consumed in the formation of the nitrate of lime must have its proportion of free oxygen disengaged, thus enriching this subterranean atmosphere with a larger portion of the exhilarating principle. The temperature of the cave is uniformly 59° F., summer and winter, and this is probably very near to the annual mean of the external air. The expansion which accompanies an elevation of temperature in the outer air is immediately felt by the denser air of the cave, and it flows out in obedience to the law of motion in fluids, and the outward current continues without interruption as long as the outer air is possessed of a higher temperature than the cave.

I was assured by those resident on the spot, that for weeks or even months, in the summer and winter, this blast of air continues with unabated force outward or inward, and yet the thermometer at a distance from the mouth always indicates the same temperature. This seems to me of itself a very convincing proof of the vast volume of the subterranean galleries; for otherwise the equilibrium being soon restored, the current would cease, or the temperature within would vary. Still it must be regarded as an interesting place for a series of observations with the barometer and thermometer continued daily for a year, and it would not be difficult to arrange such a series, if the question was esteemed to possess sufficient scientific interest to warrant the expense. If the cave had two openings at different levels, the temperature would not be uniform and there would be two currents discernible.

There is no exception to the purity of the air in the Mammoth Cave, in none of the deep pits or domes is it possible to find any accumulation of carbonic acid or other noxious gases, respiration and combustion are perfect in all parts which have yet been visited. The waters of the springs and rivers within it are all limpid and potable, and the avenues with few exceptions are dry at all seasons. I thought it very remarkable that in all its vast extent

there should be no sources of sulphuretted hydrogen and of carbonic acid.*

The phenomena of life within the cave are comparatively few but interesting. There are several insects, the largest of which is a sort of cricket with enormously long antennæ. Of this insect, numerous specimens will be found among the specimens sent to Prof. Agassiz. There are several species of Coleoptera, mostly burrowing in the nitre earth. There are some small water-insects also which I suppose are Crustacean. Unfortunately three vials containing numerous specimens of these insects were lost with my valise from the stage coach, and I fear will not be recovered. Of the fish, there are two species, one of which has been described by Dr. Wyman in the American Journal of Science, and which is entirely eyeless;† some ten or twelve specimens of the species were obtained. The second species of fish is not colorless like the first, and it has external eyes, which however are found to be quite blind.‡ The craw-fish or small crustacea inhabiting the rivers with the fish are also eyeless and uncolored, but the larger-eyed and colored craw-fish which are abundant without the cave, are also common at some seasons in the subterranean rivers, and so also it is said the fish of Green river are to be found in times of flood in the rivers of the cave. Among the collections are some of the larger-eyed craw-fish which were caught by us in the cave. The only mammal except the bats, observed in the cave, is a rat which is very abundant, judging from the tracks which they make, but so shy and secluded in their habits that they are seldom seen. We caught two of them, and fortunately male and female.

The chief points of difference from the common rat in external characters, are in the color, which is bluish, the feet and belly and throat white, the coat which is of soft *fur* and the tail also thinly furred, while the common or Norway rat is gray or brown, and covered with rough hair. The cave rat is possessed of dark black eyes, of the size of a rabbit's eye and entirely without iris; the feelers also are uncommonly long. We have satisfied ourselves that he is entirely blind when first caught, although his eyes are so large and lustrous. By keeping them however in captivity and diffuse light they gradually appeared to attain some power of vision. They feed on apples and bread, but will not at present touch animal food. There is no evidence that the cave rats ever visit the upper air, and there was no one who could tell me whether they were or were not found there by the persons who first entered this place in 1802.

* Near "Mary's Bower" there is a spring of bitter water evidently containing sulphate of magnesia, which salt is also found abundantly in some parts of the cave.

† See also Proceedings Bost. Soc. Nat. Hist., 1850, 349.

‡ For a list of the animals found in the cave as mentioned by Prof. Agassiz, see this volume, page 127.

Bats are numerous in the avenues within a mile or two of the mouth of the cave, and Mr. Mantell thinks he has secured at least two species. Several specimens are preserved in alcohol. It was not yet quite late enough in the season when we were at the cave, Oct. 16th–22d, for all the bats to be in winter quarters, as the season was very open and warm. Still in the galleries where they most abound, we found countless groups of them on the ceilings chippering and scolding for a foothold among each other. On one little patch of not over four by five inches, we counted forty bats, and were satisfied that one hundred and twenty at least were able to stand on a surface a foot square; for miles they are found in patches of various sizes, and a cursory glance satisfied us that it is quite safe to estimate them by millions. In these gloomy and silent regions where there is neither change of temperature nor difference of light to warn them of the revolving seasons, how do they know when to seek again the outer air when the winter is over and their long sleep is ended? Surely he who made them has not left them without a law for the government of their lives.

You may enquire what has formed the excavations of Mammoth Cave. I answer clearly and decidedly *water* and no other cause. No where else can we find such beautiful sculptured rocks as in Mammoth Cave; such *perfect* unequivocal and abundant proofs of the action of running water in corroding a soluble rock. The rough hewn block in the quarry, does not bear more distinct proof of the hammer and the chisel of the workman, than do the galleries of Mammoth Cave of the denuding and dissolving power of running water. At Niagara we see a vast chasm evidently cut by water for seven miles, and still in progress, but we cannot see beneath the cataract the water-worn surfaces, nor the rounded angles of the precipice—while the frosts and rains of countless winters, have reduced the walls of the chasm itself to a talus of crumbling and moss-grown rocks. But in the Mammoth Cave we see a freshness and perfection of surface, such as can be found only where the destructive agencies of meteoric causes are wholly absent, aided and quickened as those are on the upper surface by the processes of vegetable life, wholly unknown in the cave. Here we have the dry beds of subterranean rivers, exactly as they were left thousands of years ago by the stream which flowed through them when Niagara was young. No angle is less sharp, no groove or excavation less perfect than it was originally left, when the waters were suddenly drained off by cutting their way to some lower level. The very sand and rounded pebbles which pave the galleries now and formed the bed of the stream of old, have remained in many of the more distant galleries untrodden even by the foot of man. The rush of ideas

was strange and overpowering as I stood in one of these before unvisited avenues, in which the glow of a lamp had never before shone, and considered the complex chain of phenomenon which were before me. There were the delicate silicious forms of cyathophylla and encrinites, protruding from the softer limestone which had yielded to the dissolving power of the water; these carried me back to that vast and desolate ocean in which they flourished and were entombed as the crystalline matrix was slowly cast around them, mute chroniclers of a distant epoch. Then there were the long succeeding epochs of the upper secondary, and these past, the slow but resistless force of the contracting sphere elevated and drained the rocky beds of the ancient ocean: the action of meteorological causes commenced and the dissolving power of fresh water, following the almost invisible lines of structure in the rocks, began to hollow out these winding paths, slowly and yet surely. But I need not attempt to paint a picture in detail whose outlines in simple truth are so grand, and I must apologise for detaining you so long. I wish that all my scientific friends could visit the Mammoth Cave; it teaches many lessons in a manner not to be learned so well elsewhere, and in this respect I was most agreeably disappointed. I had heard that its interest was chiefly scenic; but I found it to exceed my utmost expectations as well in its illustrations of geological truth, as in the wonderful character of its features. I will not detain you with any attempts at descriptions of single parts, as no description can awaken those peculiar and deep emotions, which a personal study of its details is calculated to produce.

I know not how or where to stop, however, in my account of this interesting place. Excuse me if I trespass yet a little longer on your patience. In traversing the high vaulted galleries of the cave, our attention was occasionally arrested by the sound of falling water. We soon learned that in such cases we were in the vicinity of an entirely new feature in this subterranean region. Approaching cautiously to the spot from which the sound proceeds, we find usually a deep pit often surmounted by a dome. These pits are of various depths, but usually not less than one hundred feet, and cut down with walls of limestone so entirely vertical, that in many cases we were able to measure them from the edge with a line and plummet. When the gallery leads to the upper portion of one of these vertical excavations, it is called a *pit;* if on the other hand the approach is from beneath, it is usually called a *dome*, from the regular and arched appearance of the ceiling. These pits or domes are sometimes of almost incredible height, and I am satisfied that in one or two instances, they reach through the entire vertical thickness of all the strata composing the cave, or near three hundred feet. Such is Gorin's dome, one of the most remarkable features of the cave. Without seeing them you will

hardly credit and cannot appreciate the sharpness with which the vertical walls of this pit are moulded into architectural forms. At one point the outer diameter of the circle bounding it comes so close to one of the adjacent galleries, that the thin shell of interposed rock has been removed for a space two feet square through which as through a window, the observer may put his head and obtain an imperfect glimpse of the interior. You perceive that the loop-hole through which you look is midway between the ceiling and the first gallery below, and by a Bengal-light or other powerful illumination, a tolerable view is obtained of the vast proportions of this monolithic structure, built without hands. I was provided with the means of producing the Drummond light, and with the guide, my assistant and Mr. Mantell, we succeeded in making the perilous descent (where only by groping in the dark over profound chasms could we find a foothold) to a point some hundred feet below the opening above described. Here we erected the Drummond light, and by its aid obtained the first view of its lofty ceiling. The dome is of an irregular outline, in the main ovoidal, and from the ceiling hangs a great curtain of sculptured and vertically-grooved rock unsupported below, with the graceful outline and apparent lightness of actual drapery. A small stream of water falls from the top, which is broken into spray long before it reaches the bottom, and keeps the whole interior wet with its splashing. No gallery has been found which leads to the bottom of this most beautiful dome. We found other similar domes in which the pendant curtain just described had fallen, and portions of it but little removed from their original position, seemed poised to a second fall.

Of the mysterious rivers, with their many-tongued echoes—the mounds of mud and drift which they annually heap up,—the long miles of avenues which stretch away beyond them, rugged or smooth,—and of the vaulted ceilings, crystal grottos and gypsum coronets which tempt the mineralogist to untiring exploration, I must say nothing, for I have already gone too far in trespassing so much upon your kindness.

ART. XXXVII.—*Descriptions of new species of Fishes; from a "Synopsis of the Fishes of the Winnipisseogee and its connecting waters;"* by WILLIAM PRESCOTT, M.D. of Concord, N. H.

Read before the Association of American Geologists and Naturalists, at the meeting held in Boston, in Sept., 1847.

THE Winnipisseogee and its tributaries, watering as they do a large portion of the interior of New Hampshire, embrace nearly all the species of fresh-water fishes existing in the state.

They consist of twenty-two species ranging through twelve genera, eight families and four orders, and all belong to that extensive and numerous group denominated *bony fishes.*

Among these are the following new species.

1. SALMO SYMMETRICA. *Winnipisseogee Trout.*—There are many points of resemblance between this trout and the *Salmo confinis*, or lake trout of Dougherty, and the *Salmo amethystus* or Mackinaw trout of Kirtland, yet in many of its characteristic markings, it obviously differs from each. We observe *first* as to the form: while the Winnipisseogee *trout* is slender and symmetrical in form, a specimen measuring twenty inches in length, weighing but thirty ounces, and another of thirty-six inches but twelve and a half pounds;—the *lake trout*, as described and figured by DeKay, has a robust body and is comparatively *short* in proportion to its *weight;* a specimen measuring thirty-one inches weighing fifteen pounds.

Second, with regard to the number and arrangement of the teeth. According to DeKay the lake trout "has numerous curved teeth in the jaws with series of large teeth along the central furrow of the tongue and many series of acute teeth on the vomer and palatines." But the Winnipisseogee trout has no teeth in the central furrow of the tongue and but a single row on each of the other parts, and also on the pharyngeals.

Again, DeKay remarks that the first dorsal fin in his specimen, measuring thirty-one inches, "commenced *one* inch nearer the nose than the extremity of the caudal rays." In the Winnipisseogee trout of twenty inches in length it was *two* inches nearer the anterior extremity.

In February, 1846, previous to my having seen DeKay's report on the fishes of New York, a friend sent me a specimen of the Winnipisseogee trout, from which, at the time, I drew up the following description. *Weight* of specimen thirty ounces; *length* twenty inches; length of head four and a half inches. *Body* slender, subcylindrical. General appearance symmetrical. *Scales very* small. *Lateral line* waving the first inch, commencing a little below the superior posterior angle of the operculum and

gently descending the first half inch and ascending as much the next, when it proceeds in a straight line to the middle of the tail. *Head*, slightly flattened between the eyes. *Jaws* equal and pointed, the extremity of the *lower* received into a cavity in the *upper*, which at that place is destitute of teeth. Jaws, tongue, palatine and pharyngeals armed with a single row of small, pointed recurved teeth, which are much the largest, and less numerous in the lower jaws. Diameter of the eye half an inch; distance between the eyes one and eight-tenths inches; pupils black, irides golden.

Distance from the extremity of the jaws to the eye one and one-fifth inches; to the first dorsal fin, nine inches; to second dorsal, fourteen and a half inches; to ventrals, nine and a half inches. Length of base of first dorsal fin, where it unites with the body, two inches; or one-tenth of the length of the fish; height of the same, (longest rays,) two and a half inches; height of pectorals equal to that of the first dorsal; base and height of the ventrals, same as the anal, one and a half and two and a half inches. Caudal fin deeply forked, distance between extremities of bifurcation, four and a half inches, or equal to length of the head.

Color, light to dark brown on the back and upper part of head; sides, dark gray, above lateral line, lighter below; in some, approaching to light salmon; lower jaw, chin and abdomen, white, mottled with fuliginous; pectorals and ventrals gray, their anterior part being shaded faintly with pink. Dorsal and caudal fins dark gray.* The whole fish, including the dorsal and caudal fins, thickly sprinkled with small circular spots, of a drab color on the sides, olive on the back approaching to light salmon below. These spots become elongated and variously curved on the top of the head, and of an olive color, giving to the part a marbled appearance.

This trout is taken in great abundance by the hook through holes cut in the ice in winter, but not in such numbers as formerly. They are not unfrequently taken weighing twelve to fifteen pounds. The largest reported to have been taken weighed twenty-five pounds. By most persons it is highly esteemed, and it is generally considered an excellent fish for the table.

Genus COREGONUS, *Cuv.*—Wherever a large body of water exists in the northern portion of the United States or Canada, so far as investigation has been made, species of Coregonus have been found.

* It is worthy of remark, that the color of this fish, in common with many others, is very much influenced by the nature of the bottom upon which it feeds, being uniformly much darker when frequenting muddy than gravelly bottoms, or rapid streams. The color varies also with age, and in many instances there is a marked difference between the color of the male and the female.

Two species inhabit the Winnipisseogee; and it is probable that they will be found also in Moose-head Lake, and perhaps in other large bodies of water in the state of Maine.

Upon carefully comparing those from the Winnipisseogee with the figures and descriptions of species from the great northern lakes, it is evident that they are new and undescribed species. It is hoped that the following description may lead to a more exact comparison.

The trivial names added, are those by which they are known and designated by the inhabitants of the surrounding country.

2. Coregonus Nov-Angliæ. *The Shad Waiter.—Body*, subcylindrical, eight and eight-tenths inches in length, greatest diameter one inch, greatest height one and four-tenths inches, (or nearly one-sixth part of the whole length,) tapering gradually to either extremity, from the point of its greatest height, which is at the anterior part of the first dorsal fin. *Scales*, medium, elongated laterally, with concentric striæ. *Lateral line* commences midway between the posterior and superior angles of the operculum, and proceeds in a straight line to the middle of the tail at the insertion of the caudal rays. *Head*, very small, conical, flattened between the eyes, length contained more than six times in the length of the body including the caudal fin. *Mouth*, small and destitute of teeth. Diameter of the eye three-tenths of an inch; distance between the eyes half an inch; pupils black, irides silvery. Distance from the extremity of snout to nostrils, equal to diameter of the eye; from the same to the eye, equal to the distance between the eyes.

The snout is truncated obliquely and shut over the lower jaw, which is shorter and inclosed within the intermaxillaries, which are short, wide, thin and truncated blades.

The first dorsal fin is three and three-tenths inches from the extremity of the snout, of a triangular form, base eight-tenths inch, height of longest ray one and one-tenth, of the shortest five-tenths of an inch; the anal is higher than long; the ventrals four, and the pectorals five times higher than long; the caudal is furcated, and the distance between the extremities one and two-tenths inches.

Color of the upper part of body and head dark olive, with bluish reflections; sides silvery; beneath, white; two-thirds of the anterior portion of the pectoral and anal fins reddish, the other third white; dorsals and caudal gray, anal white; operculum and preoperculum silvery with brilliant golden reflections.

There are about ninety scales in the direction of the lateral line which is very conspicuous, and about eight in a diagonal direction from the lateral line to the first dorsal, and ten from the same to the anal fin.

3. Coregonus Neo-Hantoniensis. *The Whiting.*—Length eighteen inches; weight two pounds; greatest diameter two inches, or one-ninth its length; greatest height three and seven-tenths inches, or the height in proportion to its length is about one to five; least height, in front of the caudal fin one and three-tenths inches. Body compressed; scales large. Lateral line commences at the superior angle of the operculum, and proceeds in a direct line to the middle of the tail. Head small, arched and conical, and its length is contained more than five and a half times in the whole length of the fish. Mouth small and toothless. Diameter of the eye half an inch; distance between the eyes one inch. Distance from extremity of jaws to the eye eight tenths of an inch; to first dorsal seven and two-tenths inches; to second do. thirteen inches; to pectoral three and two-tenths inches; to ventral same as first dorsal; to anal twelve inches.

Base of first dorsal equal to the diameter of the body, height of longest rays two and three-tenths inches, shortest six-tenths inch; height of pectorals four times their length; ventral three times higher than long; anal longer than high. Caudal deeply furcated, distance between extremities of bifurcation five inches.

Color: head and back, olive brown; sides lustrous and silvery, beneath white; dorsal fins brown, pectorals and ventrals white margined with brown; operculum silvery with golden reflections, exhibiting a brilliant play of colors; pupils black; irides metallic white.

Fin rays D, 10. P, 14. V, 12. A, 10. C, (?)

4. Lota brosmiana, *Storer.*—In the paper read before the Association this fish was referred to as a *Cusk.* This error arose from the circumstance that this fish is so called by the inhabitants about the Winnipisseogee, from its close resemblance to a cusk. I had not then seen Dr. Storer's description of it. The name in the west is *Eel Pout.*

In justice to Dr. Storer I substitute his description as published in the Boston Journal of Natural History, vol. iv, p. 58, instead of my own, with the remark, that as the specimens examined by us were very near equal in size, any difference of character may be considered worthy of note.

Dr. Storer's specimen measured twenty-seven inches and weighed five and a half pounds, mine measured twenty-seven and a half inches, and weighed five pounds; the greatest breadth or lateral diameter of his was five inches, of mine four inches; the greatest depth (height) of his was four and a half inches, of mine four inches.

In common with most of our fresh-water fishes, there is considerable difference in the color of the Lota. Whilst there are many fuliginous spots on those from the lake, there are few or

none on those taken from the river. These spots are, moreover, very irregular, generally being more numerous on one side of the fish than on the other.

All the specimens I have seen were beautifully reticulated on the back and top of the head, with brown, yellow and olive. In all other respects, the description of this fish by Dr. Storer, does not materially differ from the specimens I have examined.

I conclude by citing here Dr. Storer's description of the species.

"The specimen, which was a female, was twenty-seven inches in length; the length of the head was five and a half inches. The body is very broad in front of the dorsal fin; it becomes much depressed on the sides back of the first dorsal, and tapers to the caudal fin. Its general color is yellowish; the back, between the back of the head and the dorsal fin, exhibits a reddish tint; the top of the head and the opercula are fuliginous, the latter exhibiting golden reflections in their centre. The body beneath is white. The whole body is perfectly smooth, covered by innumerable cup-shaped depressions, like that of the *Zoarchus anguillaris*, and like that species it is lubricated by a viscid secretion.

"The depth of the body at the base of the pectorals is three and a half inches; its greatest depth is four and a half inches; its depth at the vent is three and a half inches. The greatest breadth of the head across the opercula is five inches. Its breadth across the eyes is three and a quarter inches. The snout is blunt. The top of the head is flat. The distance between the eyes is less than two inches. The eyes are circular, one half inch in diameter; the nostrils are double—the posterior, half an inch in front of the eyes; the anterior, which is tubular, and furnished with a cirrhus, two lines in length, is less than half an inch in front of this. The opercula are nearly two inches in length.

"The vertical gape of the mouth, is two inches in extent; the jaws are equal; the jaws, palatine bones and pharynx are armed with numerous fine teeth, placed like those of a card. The tongue large, smooth and white. Suspended from the chin is a cirrhus one and a half inches in length.

"The lateral line commences above the operculum, and gradually curving downwards, does not reach the middle of the body, until beyond the middle of the dorsal fin. The dorsal, pectoral, anal and caudal fins are colored as well as the sides of the fish, with bluish blotches, and are margined with black. The ventral fins are white beneath, and fuliginous above.

"The first dorsal fin is situated eleven inches back of the snout; it is two inches long, one inch high, the posterior portion being barely higher than the anterior. The second dorsal fin commences half an inch back of the preceding; it is less than an inch high at the commencement, and is half an inch high at

its posterior extremity. This fin is continued nearly to the base of the tail.

"The pectoral fins are situated directly behind and beneath the posterior angle of the operculum. They measure three and a half inches across when extended, and are rounded at their posterior extremity; they are an inch deep at their base.

"The ventral fins are situated in front of the pectorals, the rays are fleshy; the first ray is an inch long; the second ray is continued an inch beyond this; the remainder of the rays are shorter than the first ray.

"The anal fin commences half an inch back of the vent and terminates on a line with the second dorsal fin; the rays are of equal height throughout. The vent is large.

"The caudal fin is three and a half inches in length; when expanded, it is three and a half inches high, and rounded at its extremity.

"The weight of this specimen was five and a half pounds.

"B, 7. D, 10–71. P, 16. V, 6. A, 68. C, 34.

"In the esophagus of this fish I found a blade of grass, and the stomach contained numerous bones of a fish, too far digested to be determined; a large quantity of viscid mucus enveloped these bones. In the intestines were several pallets, apparently of soft mud."

ART. XXXVIII.—*Meteorological Observations: Abstract of a Meteorological Journal, kept at Beloit College, Beloit, Wisconsin, for the year* 1850, *Lat.* 42° 30′, *Long.* 12° *west of Washington; elevation above Lake Michigan,* 172 *feet—above the Ocean,* 750 *feet;* by S. PEARL LATHROP, M.D., Professor of Chemistry and Natural History.

Month.	BAROMETER.			THERMOMETER.			Rain and melted snow.	Prevailing winds.
	Max.	Min.	Mean.	Max.	Min.	Mean.		
January,	28·98	27·90	28·55	46	–3	25·33	2·59	S. & N. W.
February,	29·10	27·87	28·65	60	–7	27·50	·50	N. & N. W.
March,	28·99	28·09	28·58	59	8	31·50	2·82	N. & S.
April,	29·00	28·03	28·61	78	18	40·50	2·81	N. & N. E.
May,	28·98	28·27	28·64	87	25	54·25	1·10	N. & S.
June,	28·94	28·45	28·70	90	36	69·50	7·42	S. & S. W.
July,	28·77	28·38	28·61	92	58	74·10	7·15	S. & N. W.
August,	28·83	28·38	28·62	92	51	71·00	15·73	S. & S. E.
September,	28·92	28·41	28·64	84	38	59·72	2·58	N. & S.
October,	28·95	28·32	28·63	75	19	49·50	3·30	S. & N. W.
November,	29·12	28·20	28·66	68	12	39·50	3·30	S. & N. W.
December,	29·09	28·28	28·69	45	–4	24·00	1·94	N. & N. W.
Mean,			28·63			47·20	51·24 in.	

This being the first series of observations made at this place, no accurate comparisons, of course, can be made, in any respect,

with previous years. The past year, however, is regarded by those who have longest resided here, as one of usual temperature through the summer months, and somewhat warmer than common through the autumnal months and December. The temperature of the spring months, however, is thought to have been lower than it is generally.

The mean temperature of the spring months is 42°·08; of the summer months, 71°·50; and of the autumnal months, 49°·57.

The mean temperature for the year 1850 is 47°·20; which is very nearly the temperature of the wells of the houses on the bluff upon which the College is situated.

The density of the atmosphere, as indicated by the barometer, is thought to be too low. This instrument, (as were all the instruments used in making these observations,) was made by Mr. N. B. Chamberlain, Boston, but was somewhat injured in the transporting. It is estimated, from some comparisons which have been made, that its range is about ·50 inch too low.

It ought to be remarked, also, that the latitude and longitude, as well as the elevation of these observations, have not been definitely and strictly established by mathematical observations. They are regarded, however, as being not far from correct.

The observations have been made at the hours required by the Smithsonian Institution, viz.: sunrise, 9 A. M., 3 P. M., and 9 P. M.

The amount of rain and melted snow for the year is 51·24 inches, giving the large mean of 4·27 inches per month through the year. This amount is much greater than was to be anticipated, from the great number of fair days, and the small amount of falling weather, which is very noticeable by one accustomed to the clouds and mists of the Green Mountains. The remark concerning the West, so frequently heard at the East, that "it rains here only at night and on Sundays," has been rather wonderfully established during the past year, as a large portion of the rain has fallen in the night!

Another fact observed is, that frequently the circumstances, which in Vermont are almost invariably accompanied by rain or falling weather of some kind, here pass away with only a storm of wind of greater or less force. This may be owing to the clouds being dissipated and their moisture being absorbed by the great sweep of the winds over these extensive prairies. As two-thirds of the rain for the year fell in the three summer months, and one-third in one of these months, the remainder of the year may be regarded as having been rather dry.

The amount of snow which fell in the winter of 1849–50 was less than the usual quantity, being about four or five inches. There was some sleighing for three or four weeks. The quantity of snow, as appears from the observations of those longer resident here, varies greatly in different winters.

The year which has just past is considered as having been rather more productive than usual. Though the spring was uncommonly backward, yet the temperature was so uniform that no portion of vegetation was unduly brought forward and consequently injured by untimely frosts. Fruit, of the various kinds which have been introduced into this new country, did remarkably well, and gave a fair promise of the *fruit-full* years to come. It appears to me that this cannot be otherwise than a very favorable country, both on account of soil and climate, for growing fruit of most kinds, such as apples, peaches, grapes, &c.,—certainly so, if the last fall can be taken as a criterion of the character of future autumns.

The crops of grain, particularly of wheat and corn—the great staple productions of the southern portions of Wisconsin,—are fully equal to those of any previous year. Thousands of bushels of the finest wheat, however, were lost by the great rains of July and August. A large amount of wheat cut down, but not garnered, was never removed from the fields. The farmers, from the great ease of getting seed into the ground, have become too much accustomed to sow more than they can command help to harvest and suitably secure. Another great error is their delaying to garner what is already suitably cured for that purpose, before whole fields are cut down by their *reapers*. The crop of potatoes was good and scarcely at all injured by the "rot." The growth and ripening of all the species of Cucurbitaceæ was much favored by the constant warmth of the summer months, and, though the roots of the vines were somewhat injured by the rains of these months, yet the amount produced in most cases was very remarkable. As an instance, I would mention a case related to me by a near neighbor—Deacon Woodward—of forty-four ripe and twenty unripe pumpkins being grown, in his garden, upon the vine of one seed!

Another fact worthy of note was observed in the second flowering of several species of plants, as stated in the calendar, and the appearance of grasshoppers so late in the season as the 13th of November. Not having seen these myself, I am unable to say anything of the species, neither am I sure that this fact will be deemed uncommon by naturalists. The *Cantharis cinerea* appeared in the latter part of June in great numbers. They had been noticed here the two years previous. This year, in many gardens, they completely stripped the potatoe vines of their foliage. No particular injury, however, appeared to arise from this. They also seemed to take much pleasure in feeding upon white clover, which they destroyed in a short time. Their progress was from north to south. They were in such numbers, that a half-bushel of them could have been gathered in a short time, with the appropriate means. The chinck-bug, *Lygæus leucopte-*

rus of Say, which made its appearance in some of the northern counties of Illinois, and was thought to have done great injury to the wheat crop, did not make its appearance, that I am aware of, in this state.*

There have been during the year several *heavy* storms accompanied with lightning, the most remarkable of which occurred on the 26th of April.

The atmosphere here is remarkably transparent, so much so, that the stars have an unwonted brilliancy and seem much nearer to you than in the northern portions of New England.

Another fact observed during the past year, is that of the "rotation" of the wind. The law of rotation, noticed by Dr. Dalton and more fully developed by Redfield and Dove, that the winds have a rotation from the north to the northeast, then east, southeast, and so through the points of the compass round to the north again, was sustained, with few exceptions. The number of circuits which have been made in this manner during the year, I am unable to state. Not thinking of this law of "rotation" of winds, until reminded of it by the fact here observed, proper care with respect to this point, was not had in the observations. In the absence of mountains to act as disturbing local causes, we may have here an opportunity of establishing or verifying this law in this country. Our strongest winds are those from the southwest; next to these the west and northwest. The wind very seldom blows for any length of time from the northeast or east.

Floral Calendar, &c.—Feb. 3d, the coldest day of the year. The average of the observations of the thermometer for the day being $-3°{\cdot}50$. At 4 o'clock, A. M., it stood at $-24°$.

March 22nd, Star of Bethlehem, crocus and snow-drop just coming up.

April 1st, Tulips and crown Imperial up; 4th, Soil in gardens sufficiently dry for working; 10th, Hepatica triloba and Ranunculus fascicularis in blossom; 15th, Pasque flower.

May 1st, Dutchman's Breeches, Squirrel corn, Adder's Tongue, Sanguinaria; 5th, Grapes begin to bloom; 11th, Geum vernum in flower; 14th, Missouri currant; 17th, Apple, Plum and Cherry; 20th, Flowering almond; 22nd, Tulips; 25th, Dodecatheon media.

June 5th, Common Syringa in blosson, Hypoxis erecta; 7th, Double Larkspur, Sweet William, Peonia; 12th, Green peas plenty; 14th, Garland Syringa in blossom, Strawberries ripe; 17th, Chinese Peonia and all kinds of Roses in blossom; 18th, Eschcholtzia in flower.

* If any naturalists wish specimens of this insect, I shall take pleasure in furnishing them.

July 1st, Currants ripe; 5th, Raspberries ripe; 10th, Wheat harvest commences; 22nd, Gooseberries ripe; 25th, Dahlias and Gladiolus in flower; 27th, Harvest apple ripe; 25th and 27th, the hottest days of the year, the thermometer on each of these days averaging 82°; at 3 o'clock P. M., the thermometer stood at 92°.

August 5th, Blackberries ripe; 7th, Tiger flower in blossom; 10th, Pine apple melons ripe; 15th, Watermelons ripe; 19th, Garland Syringa—*Philadelphus grandiflorus*, in flower the second time; 25th, Snow-ball—*Virburnum opulus*, in flower the second time, Green gage ripe.

Sept. 2nd, Wild Plums ripe; 8th, Corn ripe and fit for harvesting; 20th, Isabella Grape ripe; 28th, Frost for the first time, Virburnum opulus in flower through this month.

Oct. 7th, Dahlias and Tomatoes injured by the frost for the first time. Virburnum opulus in bloom up to this date.

Nov. 16th, First snow; 22nd, Ranunculus fascicularis in blossom the second time and continued in bloom through this month.

Dec. 13th, The thermometer at sunrise stood –4°, the only time during the month that it was below zero.

ART. XXXIX.—*Miscellaneous Notices;* by J. W. BAILEY.

1. *On the real nature of the so-called "orifices" in Diatomaceous shells.*—It is well known to naturalists that several of the most distinguished writers on the Diatomaceæ have asserted the existence of "apertures," "orifices" or "mouths" in the ventral surfaces of many shells belonging to this family, and have even founded classes and genera upon the supposed presence of these openings. Some years ago I expressed in this Journal my disbelief in the existence of these apertures in the following words. "There are three rounded spaces on each of the ventral faces [of Naviculæ] which I think have been mistaken for openings but which appear to me to be thicker portions of the carapace."* This opinion was founded upon a careful observation of various fragments as seen in clean fossil specimens, and I still think that by the inspection of such fragments full evidence of the truth of my opinion may be obtained. I now offer proof of another kind which removes all doubt, and shows that these markings are neither apertures nor depressions, but are in reality the thickest parts of the shell. If the shells are placed in dilute hydrofluoric acid and watched by aid of the microscope as they gradually dissolve, the thinnest parts of course dissolve first, and apertures if any exist, should become enlarged. Now the very parts which

* See this Journal, vol. xlii, p. 97, American Bacillaria, part 2.

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* See this Journal, vol. xlii, p. 97, American Bacillaria, part 2.

have been called orifices by some and depressions by others, are the last of all to disappear as the shell is dissolved. This mode of observation, beside establishing the fact that these are really the thickest parts of the shell, reveals many interesting particulars of structure in the various genera of Diatomaceæ. Thus in the large species of Pinnularia, it may be seen with even a low power, that the two parallel bands (separated by a canal) which reach from the central knob to the terminal ones, and which appear smooth before the application of the acid, become distinctly striated after their surface is dissolved off, as does also the central spot itself, showing that striæ which existed in the young shell are covered up and nearly obliterated by subsequent deposits.

In Stauroneis the cross-band and the two longitudinal bands are the last to dissolve, and these last bands, as in most of the family, appear separated by what is either a canal or a very thin portion of the shell. In Grammatophora the undulating lines are internal plates which are the last to dissolve. In Heliopelta, Actinoptychus, &c., the polygonal central spot is the last to disappear. In Isthmia, the spots on the surface, which at first appear like granular projections, are in reality thin portions of the shell, and under the action of the acid they soon become real holes. The acid also proves that the larger spots at the transverse bands are really a series of large arcuate holes in the siliceous shell, and the piers of this series of arches, remain some time after all the rest of the shell has vanished. Many other interesting facts are revealed by the action of this acid on these shells, and no one can use it without learning much with regard to their true structure.

A few directions with regard to the mode of manipulation in these experiments will probably be useful. As the fumes of the hydrofluoric acid, if they reached the lenses, would greatly injure them, I would advise experimenters (even if they have a micro-chemical stage) to protect the front face of their objectives by temporarily cementing to them a thin plate of mica by means of Canada balsam. This can be attached or removed in a few moments, and completely protects the lens without materially affecting its optical power. As mica resists the action of hydrofluoric acid much better than glass does, I prepare the cell in which the solution is to take place by cementing a bit of mica to a glass slide, and then cover all its surface except a central cell with wax. In this cell, the shells are put with a little water, and after adding a drop or two of the acid by means of a dropping rod of silver or platinum, the cell is covered with another plate of mica, and the action watched under the microscope.

2. *On the cell-membrane of Diatomaceous shells.*—If hydrofluoric acid is applied to recent Diatomaceæ, the silica soon dissolves leaving distinct, internal, flexible cell-membranes retaining

the general form of the shells. These may sometimes but not generally be detected even in the fossil specimens. When present, they materially interfere with the examination of the true nature of the markings of the siliceous shell, and should be destroyed by nitric acid and heat, before the hydrofluoric acid is employed, unless it is desired to study the cell-membrane itself. There is a curious difference in the action of hydrofluoric acid of the same strength upon specimens of fossil Diatomaceæ from different localities. Some dissolve with even too great rapidity in an acid which is slow and tedious in its action on other specimens. The Bermuda and Richmond Tripoli, and *some* specimens of fluviatile origin resist the action much longer than is usual with most specimens, whether they are recent marine, or either recent or fossil fluviatile ones. This difference is probably due to different degrees of hydration.

3. *Mode of distinguishing artificial from natural Camphor.*—By the application of polarized light the smallest portion of natural camphor may be distinguished from the artificial camphor (chlorohydrate of camphene). If small fragments of each be placed separately on glass slides, and a drop of alcohol added to each, they dissolve and speedily recrystallize. If the crystallization of the natural camphor is watched by means of the microscope and chromatic polarized light, a most beautiful display of *colored* crystals is seen, while with the artificial product nothing of the kind is witnessed.

4. *Infusoria in Hudson river Ice.*—For several years I have been in the habit of examining the mud upon the drift ice in the Hudson river, and as I find it constantly to present the same characters, I now announce the fact that it affords an abundant supply of fine specimens of marine siliceous Infusoria or Diatomaceæ. The mud upon this ice is probably in part scraped from the surface of the flats, and partly derived from the filtering of the muddy waters dashed upon its surface. Among the most common and most beautiful forms which are present, are Surirella splendida, *Ehr.*, Coscinodiscus subtilis, *Ehr.*, Triceratium favus, *Ehr.*, Biddulphia pulchella, *Gray*, Campylodiscus argus, *B.*, Cerataulus turgidus, *Ehr.*, Pinnularia, *B.*, &c., &c. The Coscinodiscus I have found in a living state as far up the river as Hyde Park. All these forms of course exist in the mud at the bottom of the river, but I have found the ice-mud to yield them most abundantly.

5. *On the detection of Sulphur.*—Dr. Playfair's beautiful salt, the nitro-prussid of soda, is justly recommended by its discoverer as the most delicate of all tests for alkaline sulphids [sulphurets].* An application of it which is very obvious although not alluded to by Dr. Playfair, is to employ it not only as a di-

* See L. E. and D. Phil. Mag., vol. xxxvi, p. 208.

rect test for alkaline sulphurets, but as an indirect one for sulphur in any of its compounds. Any substance containing sulphur will yield an alkaline sulphuret if heated with carbonate of soda, either with or without the addition of carbonaceous matter according as a deoxydizing action is or is not required. The magnificent purple which is then produced by the addition of the fused mass to a drop of the solution of the nitro-prussid will at once prove the presence of sulphur. This reaction is so easily obtained and is so decisive that the nitro-prussid of soda must take its place among the most useful adjuncts to the blowpipe tests. By means of it the presence of sulphur in the smallest particles of coagulated albumen, horn, nails, feathers, mustard seed, &c., which can be conveniently supported on a platinum wire for blowpipe experiment, may be most distinctly shown, and I have repeatedly obtained the characteristic purple tint in operating upon a piece of a single fibre of the human hair *less than an inch in length.*

ART. XL.—*On the Chemical Constitution of the Mineral, Warwickite;* by T. S. HUNT, of the Geological Commission of Canada.

THIS mineral, which had been for several years known to collectors under the name of *hypersthene*, was first proposed as a new species by Prof. C. U. Shepard in 1838;* in the following year he added some farther experiments upon its chemical constitution and deduced from them the conclusion that it was a difluorid of titanium and iron with traces of yttria.*

It occurs generally in very small and slender crystals having their edges rounded, but occasionally, as described by Shepard, in larger crystals, rarely half an inch in diameter, which are however much softer than the smaller crystals, and possess in a less degree the characteristic lustre of the cleavage planes. In February, 1846, while a student in the Laboratory of Yale College, I submitted to analysis one of these larger crystals, having a hardness a little more than 3, and the specific gravity 3·188. The examination showed the presence of titanic and silicic acids, with magnesia, alumina, protoxyd of iron, water, and a small portion of lime. A quantitative analysis gave their respective proportions as follows. Silica, 18·5, titanic acid, 28·2, protoxyd of iron, 10·59, magnesia, 22·2, alumina, 13·84, lime, 1·3, and water, 7·3 = 101·98.

The composition of this mineral differed so much from that assigned to Warwickite by Prof. Shepard, that I described it as a

* This Journal, vol. xxxiv, p. 313, and vol. xxxvi, p. 85.

new species under the name of *Enceladite.** As however the limestone in which it occurs, often contains altered and hydrated minerals, such as the well known steatitic spinels and pyroxenes, I suggested that it was itself not improbably an altered mineral, a conjecture which derived additional support from the fact that a spinel in contact with one of the crystals of Enceladite, was in part converted into a soft substance resembling serpentine. I determined therefore to examine the small hard and brilliant crystals of Warwickite which in form and cleavage so much resemble the Enceladite.

The specimen containing them was from the original locality in the vicinity of Edenville, Orange county, New York, and consisted of a white crystalline limestone enclosing small brilliant octahedrons of translucent greenish spinel, and crystalline grains of brownish or greenish yellow chondrodite, with occasional grains of serpentine. The crystals of Warwickite, which penetrate in every direction the cleavable calcareous spar, are very small, the largest being scarcely half a line in diameter, and not more than three or four in length. Their characters correspond perfectly with the description of Shepard; they are oblique rhombic prisms, but rounded both on their lateral and terminal edges, so that it is impossible to measure them; the macrodiagonal cleavage is perfect and exhibits in a high degree that metallic lustre and copper-red reflection which formerly obtained for the mineral the name of hypersthene. The exterior of the crystals is brownish black with a vitreous lustre; the surface is broken by markings or rifts, oblique to the prism and apparently corresponding to the oblique cross cleavage, observed upon the lateral cleavage planes. The surface of the crystals has a hardness of 6, (Shepard,) while that of the cleavage planes is somewhat less. When exposed to the weather, the mineral becomes soft, pulverulent and of an ochre-yellow, still however retaining the characteristic cleavage.

By the action of dilute hydrochloric acid, which does not act upon the crystals, a portion of them were freed from their gangue, and they were afterwards carefully picked out from the foreign minerals. The whole weight of the crystals which I was thus able to command was but about five decigrammes. They were first employed for a determination of the specific gravity, and after having been carefully boiled in water, to expel any airbubbles, gave the number 2·89.

The mineral was finely pulverized and the powder dried over sulphuric acid at the ordinary temperature; its color was dark purplish brown, exhibiting until the mineral was very finely divided, the coppery reflection of the cleavage surfaces.

* This Journal, 2nd Series, vol. ii, p. 31.

A. ·250 grammes of the powder were intensely ignited for some minutes in a platinum crucible; the loss of weight was ·004, and the color became of a lighter reddish brown. Sulphuric acid diluted with its bulk of water was now added, and the crucible being covered with a watch-glass, heat was applied until vapors of the sulphuric acid began to be evolved. The polish of the glass was not affected, showing the absence of fluorine. Another trial with concentrated acid upon a portion of the mineral before ignition, gave the same negative result. By a prolonged digestion with the acid, the whole was converted into a white mass, which was completely soluble in warm water, evincing the absence of silica.

B. The recent solution prepared in a carefully covered crucible, gave with ferrocyanid of potassium a pale greenish-blue precipitate, but with the ferridcyanid an immediate precipitate of a dark blue showing that iron was present as a protosalt. It was not affected by sulphuretted hydrogen.

C. The solution being largely diluted was boiled, when it threw down a large quantity of titanic acid. This being separated by a filter, and a few drops of nitric acid having been added to the boiling liquid, it was precipitated with a slight excess of caustic ammonia. The precipitate was reddish brown and gelatinous; it was washed and digested with heat, for some time, in a solution of caustic potash; the alkaline liquid, acidulated with hydrochloric acid, gave with ammonia only a few imponderable flocculi. Alumina is therefore absent.

D. The ammoniacal precipitate was then digested for some hours with a concentrated solution of carbonate of ammonia. It became darker and a portion was evidently dissolved; after filtration the ammoniacal solution was acidulated with hydrochloric acid, boiled, and ammonia added; the transparency of the liquid was disturbed only by the separation of a trace of precipitate too small to be estimated; this was regarded as titanic acid which is not wholly insoluble in carbonate of ammonia. The ammoniacal solution gave with phosphate of soda a precipitate of ammonio-phosphate of magnesia.

E. The insoluble residue from the last, having been dissolved by a drop or two of dilute sulphuric acid and, boiled, yielded a small additional quantity of titanic acid, and the filtrate precipitated by ammonia gave a substance having the appearance of pure peroxyd of iron. Its nature was verified by redissolving it, adding tartaric acid and ammonia in excess, and precipitating the metal as sulphuret.

F. The ammoniacal filtrate from C was not affected by hydrosulphuret or oxalate of ammonia, but gave by the addition of phosphate of soda a copious precipitate of phosphate of magnesia and ammonia. A portion of the solution evaporated to dryness and ignited to expel ammoniacal salts, was precipitated by

baryta, and the filtrate examined for alkalies without success. A portion of the original sulphuric solution was tested for phosphoric acid by molybdate of ammonia, but gave no indication of its presence.

From these experiments it appears that the only ingredients present in the mineral are titanic acid and magnesia, with some protoxyd of iron. There remained at my disposal only ·200 grammes of the mineral, and with this, I endeavored to ascertain the relative proportions of the constituents. It lost by intense ignition ·004 grammes, and was then decomposed as before by sulphuric acid, and dissolved in a large quantity of water, from which by boiling the greater part of the titanic acid was thrown down. Having peroxydized the iron, and added a portion of sal-ammoniac, the solution was precipitated by ammonia; the well washed precipitate having been dissolved in hydrochloric acid, a solution of bicarbonate of potash was gradually added to excess, and the ferruginous precipitate having been collected, was redissolved in hydrochloric acid, precipitated by ammonia, dried and ignited. It weighed ·022 grammes, and when analyzed after the plan described under E, gave ·018 of pure peroxyd of iron equal to ·0162 of protoxyd. The difference of ·004 grammes was considered as titanic acid, and was added to that originally precipitated, making in all ·063 grammes.

The magnesia in the first ammoniacal filtrate, and that in the solution with bicarbonate of potash, were precipitated as ammonio-phosphate which after ignition weighed ·237 grammes = ·087 of magnesia.

An accidental loss was sustained upon the original solution of the mineral, but I was obliged to complete the analysis upon that portion, for want of material; it is believed that the numbers above given, represent the respective proportions of the several constituents, and that the deficiency in their sum is no more than corresponds to the loss. We have from ·200 grammes,

Titanic acid, . .	·0630	=	31·5
Magnesia, . . .	·0870	=	43·5
Protoxyd of iron, . .	·0162	=	8·1
Loss on ignition, . .	·0040	=	2·0
	·1702		85·1

If we take the deficiency of about fifteen per cent. to represent only the three ingredients above found, we have by calculation the following as the composition of the mineral.

Titanic acid, . .	37·14	containing oxygen,		14·82
Magnesia, . .	51 30	"	"	20·55
Protoxyd of iron, .	9·55	"	"	2·11
Loss on ign., (water?)	2·00	"	"	1·72
	99·99			

If the volatile matter be regarded as not essential to the composition of the mineral, we have as the ratio of the oxygen of the titanic acid to that of the bases, 14·82 : 22·66, or very nearly 2 : 3, which leads to the formula $Ti\,O_2$, $3(Mg\,O, Fe\,O)$, or, $Ti_2\,O_3$ (M_6) in the notation of Gerhardt, or a trititanate of magnesia in which a small portion of the base is replaced by protoxyd of iron.

This interesting mineral adds another to the small number of simple titanates already known, and pertains to a different chemical type from either Perowskite or Polymignite. The Enceladite which I formerly proposed as a new species, is undoubtedly nothing more than Warwickite, altered by a process similar to that which has converted the associated spinels into steatite, the introduction of silica and water.

It might be a question whether the alumina were introduced with these ingredients, or whether in the original mineral it replaced in part the magnesia of the larger crystals, which also contain a larger proportion of iron. It is however to be remarked in the first place that as far as examined, steatitic pseudomorphs do not appear to contain alumina, unless it has been an original ingredient in the composition of the mineral; and secondly, that excluding the silica and water, the ratio between the oxygen of the titanic acid, and that of the magnesia, protoxyd of iron and alumina in the Enceladite is very nearly 2 : 3, as in the Warwickite. I am therefore inclined to regard, the alumina as Al^3 (Gerhardt) as replacing in part the magnesia of the larger crystals. The analysis of some of these in an unaltered condition would be very desirable to settle the question.

I avail myself of this occasion to correct an error which occurs in the "Annual Report of the Progress of Chemistry" for 1847–48, by Profs. Liebig and Kopp. In citing my description of the Enceladite, they state that I regard the mineral as an altered titanic iron.* The compiler has however failed to apprehend my meaning; in suggesting its probable metamorphic origin, I remarked that the form of the crystal was inconsistent with the idea that it could be derived from a titanic iron by the introduction of a silicate of magnesia and water.† I had not at that time the present results to guide me in forming a notion of the real nature of the metamorphic action.‡

Montreal, C. E., March 12th, 1851.

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* English Edition, vol. ii, p. 428. † This Journal, 2nd Series, vol. ii, p. 36.

‡ In the analysis of the Enceladite, the opinion was advanced that the titanium existed in the mineral as titanic oxyd, $Ti_2\,O_3$. M. Rammelsberg however (Handw. 3d Sup. 41) inclines to the view that it exists as titanic acid, an opinion which today I am not disposed to dispute, although I may remark that whatever value may be attached to the reaction which I then adduced in favor of the idea,—(the blue color fading into white on exposure to the air, which was produced on heating the mineral with concentrated sulphuric acid,)—it was adduced independently of me about the same time by Scheerer in support of his view of the existence of titanic oxyd in the titanic iron of Hitteroë. (Annalen der Physik und Chemie, t. lxiv, p. 489.)

Art. XLI.—*On Coral Reefs and Islands;* by James D. Dana.—Part I.

From the Report on Geology of the Exploring Expedition under Capt. Wilkes, U.S.N.

1. General Features of Coral Reefs and Islands.

The general features of reefs and coral islands have often been delineated by travellers, and are probably almost as familiar to the reader as the scenes of the land around us. Yet a few brief remarks on this point form a necessary introduction to the more minute descriptions of structure which follow.

Coral reefs.—A wide platform of rock covered with the sea except at low tide, borders most of the high islands of the Pacific. It is a vast accumulation of coral, based upon the bottom in the shallow waters of the shores. This bank or table of coral rock, is of varying width, from a few hundred feet to a mile or more; and although the surface is usually nearly flat, it is often intersected by irregular boat channels, or occasionally encloses large bays, affording harbor protection to scores of ships. In very many instances the reef stands at a distance from the shores like an artificial mole, leaving a wide and deep channel between it and the land; and within this channel are other coral reefs, some in scattered patches and others attached to the shore. The inner reef in these cases, is distinguished as the *fringing* reef, and the outer as the *barrier* reef. The sea rolls in heavy surges against the outer margin of the barrier; but the still waters of a lake prevail within, affording safe navigation for the tottling canoe sometimes through the whole circuit of an island: and not unfrequently, ships may pass, as by an internal canal, from harbor to harbor around the island. The reef is covered by the sea at high tide, yet the smoother waters indicate its extent, and a line of breakers its outline. Occasionally a green island rises from the reef, and in some instances, a grove of palms stretches along the barrier for miles, where the action of the sea has raised the coral structure above the waves.

The sketch annexed conveys some idea of the peculiar features presented by a Pacific island and its encircling reefs, though in order to fill out the scene, the jagged heights and deep gorges of the islands should be covered with forests and the shores with groves and native villages. The coral platform which borders the

shore is represented with its usual uneven line,—its broad harbors with a narrow entrance,—and to the left an irregular ship channel running between the inner or fringing reef, and the outer or barrier. At a single place the sea is faced by a cliff; and here owing to the boldness of the shores and depth of waters, the reef is wanting. To the right there is only a fringing reef.

Coral islands.—Coral islands resemble the reefs just described, except that a lake or lagoon is incircled instead of a mountainous island. A narrow rim of coral reef, generally but a few hundred

yards wide, stretches around the enclosed waters. In some parts it is so low that the waves are still dashing over it into the lagoon; and in others it is still verdant with the rich foliage of the tropics. The coral-made land when highest is seldom elevated over eight or ten feet above high tide.

When first seen from the deck of a vessel, only a series of dark points is descried just above the horizon. Shortly after, the points enlarge into the plumed tops of cocoa-nut trees, and a line of green, interrupted at intervals, is traced along the water's surface. Approaching still nearer, the lake and its belt of verdure are spread out before the eye, and a scene of more interest can scarcely be imagined. The surf beating loud and heavy along the margin of the reef, presents a strange contrast to the prospect beyond,—the white coral beach, the massy foliage of the grove, and the embosomed lake with its tiny islets. The color of the lagoon water is often as blue as the ocean, although but fifteen or twenty fathoms deep; yet shades of green and yellow are intermingled, where patches of sand or coral-knolls are near the surface; and the green is a delicate apple-shade, quite unlike the usual muddy tint of shallow waters.

The belt of verdure, though sometimes continuous around the lagoon is usually broken in some parts into islets which are separated by varying intervals of bare reef; and through one or more of these intervals, a ship-channel occasionally opens into the lagoon. The larger coral islands are thus a string of islands arranged along a line of coral reef. The king of the Maldives bears the high-sounding title of "Ibrahim Sultan King of the thirteen Atollons and Twelve Thousand Isles;" which Capt. W. F. W. Owen, R. N., remarks, is no exaggeration.

The usual features of these islands are presented in the above sketch. The narrow belt is seen to consist of several patches of vegetation; and within are the quiet waters which offer a retreat for vessels whenever there is an opening to the lagoon.

A few small coral islands are simple reefs without lagoons. In some cases they are bare banks of coral; but generally, the usual vegetation of the islands has obtained a foothold, and affords some protection against the glare of the coral sand.

With these general remarks we may enter upon the more particular consideration of the characters of reefs and islands.

2. Characters of Fringing and Barrier Reefs.

a. General features.

Fringing reefs have been described as those that directly adjoin the shores of an island; and the *barrier*, as the exterior reefs, separated from the fringing reef, or from the shores when there is no inner reef, by an open channel.

While there are only narrow shore-reefs to many islands, around others, a distant barrier extends like an artificial mole, sometimes ten or even fifteen miles from the land, and enclosing not only one, but at times several islands. Between the narrow fringing platform and these remote barriers, there is every possible variation as to extent and relative position. The inner channel is sometimes barely deep enough at low tide for canoes, or for long distances may be wanting entirely. Then again, it is a narrow intricate passage, obstructed by knolls or patches of coral, rendering the navigation quite dangerous. Again, it is for miles in length an open sea, in which ships find room to beat against a head wind with a depth of twenty, thirty, or even fifty fathoms. Yet hidden reefs make caution necessary. Patches from a few square feet to many square miles in extent are met with over the broad area enclosed by these distant barriers.

These varieties of form and position are well exemplified in a single group of islands—the Feejees; and we would refer the reader to a reduced copy of the admirable chart of this Archipelago by the Expedition.*

Near the middle of the chart is the island *Goro;* its shores, excepting the western, are bordered by a fringing reef. The island *Angau*, south of Goro, is encircled by a coral breakwater, which on the southern and western sides runs far from the shores, and is a proper barrier reef, while on the eastern side, the same reef is attached to the coast and is a fringing reef. From these examples it is perceived that there is no proper distinction as regards mode of formation between barrier and fringing reefs. It is also apparent that while a reef is sometimes quite encircling, in other instances it is interrupted along certain shores, or may be wanting along a large part of a line of coast; and occasionally the reef may be confined to a single point of an island.

* For this chart, see Capt. Wilkes's Narrative of the Exploring Expedition, or the Geological Report of the writer.

Above Angau lies *Nairai;* though a smaller island than Angau the barrier reef is of greater extent, and stretches off far from the shores. To the eastward of Nairai are *Vatu Rera*, *Chichia*, and *Naiau*, other examples of islands fringed around with narrow reefs. *Lakemba*, a little more to the southward, is also encircled with coral: but on the east side the reef is a distant barrier. In *Aiva*, immediately south of Lakemba, the same structure is exemplified; but the coral ring is singularly large for the little spots of land it encloses. The *Argo Reef*, east of Lakemba, is a still larger barrier, encircling two points of rock called Bacon's isles. It is actually a large lagoon island, twenty miles long, with some coral islets in the lagoon, and two of basaltic constitution, the largest of which is only a mile in diameter. Aiva and Lakemba are in fact other lagoon islands, in which the rocky islands of the interior bear a larger proportion to the whole area. The same view is farther illustrated by comparing the Argo reef with Nairai, Angau, or Moala: the only difference in these cases consists in the greater distance of the reef from the shores which it encircles, and the smaller extent of the enclosed land.

Passing to the large islands *Vanua Levu* and *Viti Levu*, we observe the same peculiarities illustrated on a much grander scale. Along the southern shores of Viti Levu, the coral reef lies close against the coast; and the same is seen on the east side and north extremity of Vanua Levu. But on the west side of these islands, this reef stretches far off from the land, and in some parts is even twenty-five miles distant, with a broad sea within. This sea, however, is obstructed by reefs, and besides, along the shores there are proper fringing reefs.

The forms of encircling reefs depend evidently to a great extent on that of the land they enclose. That this is the case even in the Argo reef and such other examples as offer now but a single rock above the surface of the enclosed lagoon, we shall endeavor to make apparent, if not already so, when the cause of the forms of coral islands is under discussion. Yet it is also evident that this correspondence is not exact, for many parts of the shores, and sometimes more than half the coast, may be exposed to the sea, while other portions are protected by a wide barrier.

In recapitulation, we remark, that reefs around islands may be (1) entirely encircling; or they may be (2) confined to a larger or a smaller portion of the coast, either continuous or interrupted: they may (3) constitute throughout a distant barrier; or (4) the reef may be fringing in one part and a barrier in another; or (5) it may be fringing alone: the barrier may be (6) at great distances from the shores, with a wide sea within, or (7) it may so unite to the fringing reef that the channel between will hardly float a canoe. These points are fully sustained by all reef regions.

A wide difference in the extent of reefs would be inferred from these facts. There is the mere point of coral rock; and again, as for example, west of the two large Feejee islands, there may be three thousand square miles of continuous reef-ground, occupied with coral patches and intermediate channels or seas. The enclosing barrier off Vanua Levu alone is more than one hundred miles long. The Exploring Isles, in the eastern part of the Feejee group, have a barrier eighty miles in circuit. New Caledonia, as often cited, has a reef along its whole western shores, a distance of two hundred and fifty miles, and it extends one hundred and fifty miles farther north, adding this much to the length of the island. The great Australian barrier forms a broken line, a thousand miles in length, lying off the coast from the Northern Cape to the tropical circle; and the channel within is in some parts sixty miles from the coast, with a depth of thirty to sixty fathoms.

The seas outside of the lines of coral reef are often unfathomable within a short distance of the line of breakers.

b. Structure of Reef Formations.

In the description of reef grounds or reef-formations there are several distinct subjects for consideration, as is obvious from the preceding remarks. These are—

1. *Outer reefs*, or reefs formed from the growth of corals exposed to the open seas. Of this character, are all proper barrier reefs, and such fringing reefs as are unprotected by a barrier.

2. *Inner reefs*, or reefs formed in quiet water between a barrier and the shores of an island.

3. *Channels* or *seas within barriers*, which may receive detritus either from the reefs, or the shores, or from both of these sources combined.

4. *Beaches and beach formations*, produced by coral accumulations on the shores through the action of the sea and winds.

The outer and inner reefs, channels, and beaches, act each their part in producing the coral formations in progress about islands.

Outer reefs.—The outer reefs or flats of coral rock receive the waves along their margin; and the outline exposed to this action is very much cut up with deep channels which give passage to the advancing waters, and to the currents that flow back in preparation for the next breaker. This margin, which we have said rises but little above low-tide level, usually slopes beneath the water at an angle of forty to seventy degrees to a depth of three to eight fathoms; thence the waters deepen very gradually for one to five hundred yards out, and from this there is finally an abrupt descent, generally by an angle of at least forty degrees to depths beyond the reach of a sounding lead. There is a great difference in the rapidity with which the water deepens, as might

be inferred from the varied character of submarine slopes; in some cases the shallow waters may extend for two or three miles beyond the reef, but it is far more common to meet with the opposite extreme—unfathomable depths within a few hundred feet.

The growing corals are mostly confined to the shallow waters of the reef, and to its sloping margin up which they extend to within a foot or less of the surface. In these shallow waters the various zoophytes at times are crowded over extensive areas; yet very often they occur only in patches scattered throughout large fields of coral debris. The top of the reef is mostly destitute of life, and consists of the naked coral rock, more or less covered with coral sand. Yet there are some shallow pools, especially towards the outer limits, which abound in corals.

The exposed edge of the reef is commonly raised a few inches above the general surface, and is, therefore, the first part laid bare by the retreating tide, although a dangerous place for a ramble, on account of the heavy breakers. Though very uneven, the surface has generally a smooth, water-worn appearance, and is spotted with various shades of pink and purple. These colors, as observed by Chamisso, are due to incrusting Nullipores, that grow like lichens over the rock: they are vegetable in nature, though composed mostly of lime. Other nodular and branching Nullipores, some sprigs of Madrepores, and a few of Astræas grow in the more sheltered cavities, where they are not easily dislodged by the waves; and among them, despite the breakers, cling numerous echini, asterias, and actiniæ. The gradual wear of the reefs by the wash of the sea is prevented, to a great extent, by these Nullipore incrustations, as was pointed out by Darwin.* He states that on Keeling's Island they constitute a layer two or three feet in thickness, with a breadth of twenty feet. They are abundant on the Paumotu reefs.

The outer reefs are distinguished in many parts from the inner by becoming covered with accumulations of coral fragments and sand, which are thrown up by the waves: finding a lodgment some distance back from the margin of the reef, the accumulations gradually increase, till in many instances they form dry land, and prepare the way for vegetation. Such effects are mostly confined, however, to the sides open to the prevailing wind, and are generally of limited extent. Occasionally, as at Bolabola, the reef for miles in length is changed from the submerged coral bank into a habitable islet—a green belt to the island of rocks and forests within. The causes and the result are much the same as in the case of the lagoon island, and the steps in the process will be more particularly described when treating of the coral atoll.

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* Darwin on Coral Reefs, London, 1842, page 9, and elsewhere.

The rock of the reef, wherever broken, exhibits a compact texture. In some parts it consists of coral fragments of quite large size firmly cemented: other portions are a finer coral breccia, or conglomerate: and still others, more common, are solid white limestones, as impalpable and homogeneous in texture as the secondary limestone of our continents, and usually much harder. It is rare to meet with any corals in this reef-rock retaining the original position of growth. It is at once apparent that the rock consists of the debris of the coral fields, consolidated by a calcareous cement; and the great abundance of the finer variety of rock indicates that much of it has originated from coral sand or mud. Wherever broken, it is found to present the same character as here described, a texture indicating a detritus origin. This reef-rock is formed in the midst of the waves; and we shall hereafter show that to this fact it owes many of its peculiarities. Besides corals, the shells of the seas contribute to it, and it sometimes contains them as fossils, along with bones of fish, exuviæ of crabs, spines and fragments of echini, and other remains of organic life inhabiting reef-grounds.

Inner reefs.—In the still waters of the inner channels or lagoons, when of large extent, we find corals growing in their greatest perfection, and the richest views are presented to the explorer of coral scenery. There are many regions—in the Feejes, examples are common—where a remote barrier encloses as pure a sea as the ocean beyond; and the greatest agitation is only such as the wind may excite on a narrow lake or channel. This condition gives rise to some important peculiarities of structure in the inner reefs.

In the general appearance of the surface, however, they much resemble the outer reefs. They are nearly flat, and though mostly bare of life, and much covered with coral sand, there are seldom any large accumulations of coral debris. The margin is generally less abrupt; yet there is every variety, from the gradually sloping bed of corals to the bluff declivity with its clinging clumps. In different parts, there are many portions still under water at the lowest tides; and here, (as well as upon the outer banks,) fine fishing sport is afforded the natives, who wade out at ebb tide with spears, pronged sticks, and nets, to supply themselves with food. The lover of the marvellous may find abundant gratification by joining in such a ramble; among coral plants and flowers, with fishes of fantastic colors, starfish, echini, and myriads of other beings which science alone has named, fit inhabitants of a coral world, there is on every side occasion for surprise and admiration.

Between the large reefs, which spread a broad surface at the water's edge of lifeless coral rock, sometimes of great extent, there are other patches, still submerged, which are covered with growing corals throughout. They are of different elevations; and though at times but a few yards in breadth, there is often along-

side of them a depth of many fathoms. They sometimes seem to grow up from a narrow base, like a mushroom; and a ship striking one with her keel may crush it and glide on. More frequently, they are below like the solid reef above described, and the contest is more likely to be fatal to the vessel than to the coral patch. Corals grow over them, as in the shallow waters about other reefs; and, as elsewhere, there are deep cavities among the congregated corals, in which a lead will sometimes sink to a depth of several feet, or even fathoms. These holes about growing reefs often give much annoyance to the boat which may venture to anchor upon them; and in many an instance in the course of the surveys, diving was the only resource left for freeing the foul anchor.

The rock of the inner reefs is peculiar in being but sparingly fragmentary. The corals composing it stand to a great extent as they grew; yet it is not less compact or firm in its texture than the rock of the outer reefs. The cavities among the branches and growing masses gradually become filled with coral sand, and the whole is finally cemented and thoroughly compacted. At Tongatabu and among the Feejee Islands, reefs thus made of corals standing in their growing positjons are common. Though now mere dead rock, the limits of the several constituent coral masses may be distinctly made out. Some individual specimens of Porites in the rock of the inner reef of Tongatabu were twenty-five feet in diameter; and Astræas and Meandrinas, both there and in the Feejees, measured twelve to fifteen feet. These corals, when growing beneath the water, form solid hemispheres, or rounded hillocks; but on reaching the surface, the top dies, and enlargement takes place only on the sides. In this manner the hemisphere is finally changed to a broad cylinder with a flat top. This was the condition of the Astræas and Porites in the reef-rock referred to. The platform looks like a Cyclopean pavement, except that the cementing material, filling in between the huge masses, is more solid than any work of art: it even exceeds in compactness the corals themselves. Other portions of these reefs consist of *branching* corals, with the intervals filled in by sand and small fragments; for even in the more still waters fragments are to some extent produced.* There is also to be found here, and frequently over large areas, the solid white limestone already described, showing internally no evidence of its coral origin, and containing rarely a few shells or imbedded fossils.

The formation of the inner reefs goes on at a less rapid rate than that of the outer, as the process depends on growth unaided, except in a comparatively small degree, by the action of the waves. Moreover, as we shall explain more particularly in another place,

* A rock of this kind is often used for buildings and for walls on the island of Oahu. It consists mainly of Porites, and in many parts is still cavernous, or but imperfectly cemented. It is the material of the large church at Honolulu.

impure or fresh waters and currents often operate to retard their growth.

Owing to the last mentioned cause, the inner reefs are not usually joined close to the beach. They stand off a little, separated by an interval of shallow water. At Mathuata, in the Feejees, however, the reef extends quite up; and it is the more remarkable as the country is a plain, the site of a Feejee village, and a mile or two back stands a high bluff. On an island off this part of Vanua Lebu is another example of this fact, and many more might be cited. In such cases, however, there is evidence that the shores upon which the corals grew were bare rocks, instead of moving beach-sands.

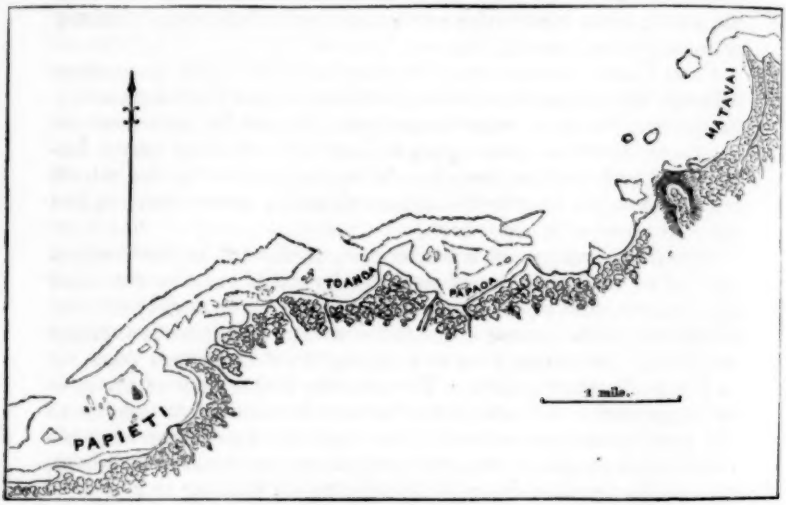
From these descriptions it appears that the main distinction between the inner and outer reefs consists in the less fragmentary character of the rock in the former case, the less frequent accumulations of debris on their upper surface, and the more varied features and slopes of the margin. Moreover, the Nullipores, which seem to flourish best in the breakers, are of less extent, or but sparingly met with elsewhere.

The inner margin of a barrier reef, it should be observed, is entitled to rank with inner reefs, as its corals grow in the same quiet waters, and under like circumstances. The variety of coral zoophytes is also greater in the stiller waters, and there are species peculiar to the different regions, as explained in another place.

Channels among reefs.—To complete this review of the general appearance and constitution of reef formations, it remains to add some particulars respecting the channels which intervene between coral patches, or separate them from the shores of an island, and also to describe the coral accumulations forming beaches.

The reef of New Holland has been instanced as affording an example of one of the larger reef-channels, varying from thirty to sixty miles in width, and as many fathoms in depth. The reefs west of the large Feejee Islands offer another remarkable example, the reef-grounds being in some parts twenty-five miles wide, and the waters within the barrier, where sounded, twelve to forty fathoms in depth. The barrier in this instance may be from a few hundred yards to a half a mile in width; and some of the inner patches are of the same extent; but by far the larger part of the reef-ground is covered with deep waters, mostly blue like the ocean, and as clear and pure. The sloop of war Peacock sailed along the west coast of both Viti Lebu and Vanua Lebu, within the inner reefs, a distance exceeding two hundred miles. The island of Tahiti on its northern side presents us with a good illustration of a narrow channel, and at the same time exhibits the usual broken or interrupted character of reefs. This is seen in the following cut in which the reefs, both fringing and barrier, are the parts enclosed by dotted lines. The outer reef

extends half to two-thirds of a mile from the shore. Within it, between Papieti and Matavai, there is an irregular ship channel, varying from three to twenty fathoms in depth. Occasionally it enlarges into harbors; and in other parts it is very intricate, though throughout navigable by large vessels. The island of Upolu, of the Samoan Group, is bordered by a reef nearly a mile wide on part of its northern shore; but the waters within are too shallow for a canoe at low tide; and therefore, notwithstanding its extent, the reef is rather a fringing than a barrier reef.



PART OF THE NORTH SHORE OF TAHITI.

The bottom of the channels or lagoons takes its character, as regards the material constituting it, either from the reefs, a source of calcareous sand and fragments, or from the earthy detritus of the island streams. At Upolu, the white coral sand of the reefs, (or in more general terms the reef debris,) forms the bottom; in some places it had the consistence of mud, and it was seldom observed to be covered with coarse material. There were some small patches of coral over it, and here and there a growing mass of Porites. The fresh waters of the shores do not flow over these wide reefs as there is no proper inner channel, and there is consequently no shore detritus mingled with the reef debris. At Tahiti, the sounding lead usually brought up sand, shells, and fragments of coral. At Tongatabu, the bottom, where the Peacock anchored, was a grayish blue mud, appearing as plastic as common clay; it consisted solely of comminuted coral and shells, with coloring matter probably from vegetable decomposition.

To the west of the larger Feejee islands, soundings commonly indicated a bottom of basaltic mud, and this material was frequently brought up with our dredges. On the north side of Vanua Lebu, a stream has so filled with its detritus the wide channel into which it empties, that for a mile our ship dragged its keel in the mud, although elsewhere the water had been from twelve to twenty fathoms deep; and at least half a dozen square miles of land had been added to the shores from this source. Though due principally to shore material, the reefs have probably added somewhat to these accumulations; yet little coral sand can be detected in the mud by the eye, and the proportion is certainly very small. In many places where we anchored, having the reef not more than five hundred yards from the ship, we might have judged, from the character of the bottom, that there were no corals nor shells within many miles. When the materials from both sources, the shore and the reef, are mingled, the proportion will necessarily depend on the proximity to the mouths of streams, the breadth of the inner waters or channels, and the direction and force of the currents. These tidal currents often have great strength, and are much modified and increased in force at certain places, or diminished in others, by the position of the reef with reference to the land. Sweeping on, they carry off the coral debris from some regions to others distant; and again they bear along only the shore detritus, and distribute it. It is thus seen that the same region may differ widely in its adjacent parts, and seemingly afford evidence in one place that there is no coral near, and in another no basaltic land, although either is within a few rods, or even close along side. The extent of the land in proportion to the reef will have an obvious effect upon the character of the channel or lagoon depositions. When the island stands like Bacon's isles, (Feejees,) as a mere point of rock in a wide sea enclosed by a distant barrier, the streams of the land are small and their detritus quite limited in amount. In such a case, the reef and the growing patches scattered over the lagoon, are the sources of nearly all the material that is accumulated upon the bottom.

Shore accumulations.—The wide coral banks and the enclosed channels greatly enlarge the limits tributary to the islands they encircle. They afford extensive fishing grounds for the natives and internal waters which enable them to practice and improve their skill in navigation, and communicate without danger between distant settlements; and the effect is evident in the spirit of maritime enterprise which characterizes the islanders: for these circumstances have favored the construction of large sail-canoes, in which they venture beyond their own land, and often undertake voyages hundreds of miles in length. Instead of a rock-bound coast, harborless and thinly habitable, like most extra-tropical islands, the shores are blooming to the very edge, and

wide plains are spread out with breadfruit and other tropical productions. Ports, safe for scores of vessels, are also opened by the same means, and some islands number a dozen, when the unprotected shores would have hardly offered a single good anchorage. Coral reefs are sometimes viewed as only traps to surprise and wreck the unwary mariner. But one who has visited the dreary prison-house, St. Helena, can have some appreciation of the benefits derived from the growth of the zoophyte.

The area of level shores, alluded to as added to many of the high islands by this means, is one of the most striking of these benefits. These plains are sometimes of large extent. The reefs stop the detritus from the hills, and are thus the means of its being added again to the land: they prevent, therefore, the waste which is constantly going on about islands without such barriers; for the ocean not only encroaches upon the unguarded shores of the smaller islands, but carries off whatever the streams may empty into it. The delta of Rewa, on Viti Lebu, resulting from the detritus accumulations of a large river, covers nearly sixty square miles. This is an extreme case in the Pacific, as few islands are so large, and consequently rivers of such magnitude are not common. But there is rarely an island which has not at least some narrow plains from this source; and upon them the villages of the natives are usually situated. Around Tahiti these plains are from half a mile to two or three miles in width, and the cocoanut and breadfruit groves are mostly confined to them.

Beach sandrock.—Besides the accumulations from a shore source, there are also beach formations derived from the reefs. The tides and the attending currents carry to the shores more or less coral sand with shells and other reef-relics, and these sometimes form large deposits. The material is mostly like common sand in fineness, but often somewhat coarser, or even like a bank of pebbles. When the barrier is distant, only the sand and smaller pebbles are met with; but if the reef is quite narrow, there may be larger fragments and masses of coral rock.

These deposits become cemented by being alternately moistened and dried, through the action of the recurring tides, and the wash of the sea on the shores. The waters take up some carbonate of lime which is deposited and hardens among the particles on the evaporation of the moisture at the retreat of the tides. In some places the grains are loosely coherent, and seem to be united only by the few points in contact; and with a little care, the calcareous coating which caused the union may be distinctly traced out. In other cases, the sand has been changed to an oolite, or to a solid rock, the interstices having been filled till a compact mass was formed. Generally, even the most solid varieties show evidence of a sand origin, and in this they differ from the reef-rock. The pebbly beds produce a pudding-stone of coral.

In all instances observed, these calcareous sand-rocks or conglomerates form a number of parallel layers along the coast, which dip regularly at an angle of five to eight degrees towards the water. The layers are from a few inches to a foot in thickness. They appear as if they had been tilted by some force from below, and are seen to outcrop successively, on receding from the water. Tutuila and Upolu in the Navigator Group, and Oahu in the Hawaiian, afforded us many examples of these beach formations. They seldom rise more than a few inches above high tide. At certain localities they appear to have been washed away after they were formed; and occasionally large masses or slabs have been uplifted by the sea, and thrown back on the beach.

Deposits of the same kind sometimes included detritus from the hills. Black basaltic pebbles are thus cemented by the white calcareous material, producing a rock of very singular appearance. Near Diamond Hill on Oahu, is a good locality for observing the steps in its formation. Many of the pebbles of the beach are covered with a thin incrustation of carbonate of lime, appearing as if they had been dipped in milk, and others are actually cemented, yet so weakly that the fingers easily break them apart.

The lime in solution in waters washing over these coral shores, is also at times deposited in the cavities or seams of the basaltic rocks; the cavities of the lava or basalt become filled with white calcareous kernels, and the cellular lava is changed into an amygdaloid. In large cavities or caverns, it often forms stalactites or stalagmitic incrustations.*

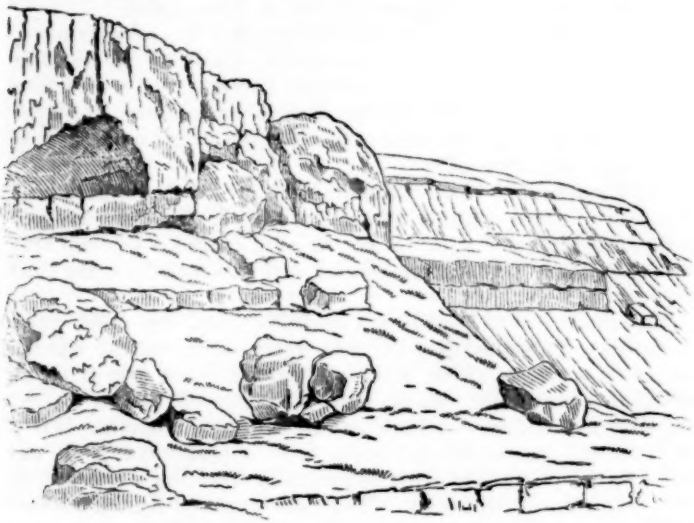
Drift sand-rock.—Still another kind of beach formation is going on in some regions through the agency of the winds in connection with the sea. It occurs only on the windward side of islands when the reefs are narrow, and proceeds from the drift sands.

The drifts resemble ordinary sand-drifts, and are often quite extensive. On Oahu, they occur at intervals around the eastern shores, from the *northern* cape, to Diamond Point which forms the *south* cape of the island,—the part exposed to the trades; and they are in some places twenty to forty feet in height. They are most remarkable on the north cape, a prominent point exposed to the winds that blow occasionally from the westward, as well as to the regular trades. They also occur on Kauai, another of the Hawaiian Islands. But at Upolu, (Samoa,) where the protecting reefs are broad, I met with no instance worthy of mention.

These sand-banks, through the agency of infiltrating waters, fresh or salt, become cemented into a sand-rock, more or less fri-

* Similar facts are stated by Mr. Darwin as observed on the shores of Ascension, and many interesting particulars are given respecting calcareous incrustations on coasts.—See Volc. Islands, p. 49. They were observed by the writer upon Madeira, in St. Jago, one of the Cape Verds, as well as among the basaltic islands of the Pacific.

able. The rock consists of thin layers or laminæ, which are very distinct, and indicate, generally, every successive drift of sand which puffs of wind had added in the course of its formation: and where a heavier gale had blown off the top of a drift, and new accumulations again completed it, the whole history is distinctly displayed in the rock. Several catastrophes of this kind may be made out from the character of the lamination in the sand-bluffs on the north side of Oahu. Since their formation, this island has undergone an elevation of twenty-five or thirty feet; these hills, once on the shores, are now seventy feet above the level of the sea, and they face the water with a bluff front (due to degradation), in which the lamination is finely exposed to view. The structure is best seen in a transverse section, presented on the west side. The layers are but a fraction of an inch thick: at one of the hills large slate-like slabs may be obtained; they have a sanded surface, but are so hard within as to clink under the hammer. A particular description of these bluffs is given in the author's remarks on the geology of the Hawaiian islands.



BLUFFS OF CORAL SAND-ROCK, NORTH SHORE OF OAHU.

One of the most interesting facts, observed in connection with these drift hills, is the absence of shells, and even of fragments of shells or corals, sufficiently large to be referred to either of these sources. The material is a fine sand, without organic remains, although situated on shores off which, within a hundred yards, there are shells and corals innumerable.

c. Thickness of reefs.

We have considered in the preceding pages the peculiarities of form and structure characterizing the reef formations bordering islands and continents, and their influence upon the enclosed land. Could we raise one of these coral-bound islands from the waves, we should find that the reefs stand upon the submarine slopes, like massy structures of artificial masonry ; some forming a broad flat platform or shelf ranging around the land, and others encircling it like vast ramparts, perhaps a hundred miles or more in circuit. The reefs that were near the water-line of the coast would be seen to have stood in the shallowest water, while the outer ramparts rested on the more deeply submerged slopes. Indeed, it is obvious that with a given slope to the declivity of the land, the thickness of the reef resting upon it may be directly determined, as it would be twice as great two hundred feet from the shore as at one hundred feet. The only difficulty, therefore, in correctly determining the depth or thickness of any given reef, arises from the uncertainty with regard to the submarine slope of the land. It is, however, admitted as the result of extensive observation, that in general these slopes correspond nearly with those of the land above water. Mr. Darwin has thus estimated the thickness of the reefs of the Gambier Group and some other Pacific islands, and he arrives at the conclusion, as his figures indicate, that some coral reefs, at their outer limits, are at least *two thousand feet* in thickness.

It will be shown in another part of this volume, that the mountain slopes of the islands of the Pacific, except when increased by degrading agents, cannot be assumed to exceed twelve or fourteen degrees, and they are often but half this amount. The slopes of Mauna Kea and Mauna Loa, island of Hawaii, do not average over eight degrees. On the north side of Upolu, where the reefs are wide, the inclination is from three to six degrees. Throughout the Pacific, the *steeper* slopes of the mountains are due to agencies which cannot be shown to have affected the submarine slopes, excepting in cases of disruption of islands by forces below.

Assuming *eight* degrees as the mean inclination, we should have for the depth of reef, (or water,) one mile from the shore, 740 feet ; or assuming *five* degrees, 460 feet. Adopting the first estimate, the Gambier Group would give for the outer reef a thickness of at least 1750 feet ; or with the second, 1150 feet. The island of Tahiti, (taking the north side for data,) would give in the same manner 250 feet by the last estimate, which we judge to be most correct ; Upolu, by the same estimate, 440 feet. The deduction for Upolu may be too large: taking three degrees as the inclination, it gives 260 for the thickness at the outer margin. The results are sufficiently accurate to satisfy us of the great thickness of many barrier reefs.

These calculations, however, are liable to error from many sources. Very different results might generally be obtained from different sides of the same island; and the same group often contains islands without reefs, and others with reefs one or even several miles from the shores. But since we may show that the absence of a reef or its limited extent may be traced to some causes restricting or modifying its formation, it is obvious that the error would probably be on the side of too low an estimate. Adjacent to the larger islands, such as those of Vanua Levu and New Holland, the error might be of the opposite kind; for the slopes of the land are of a more complex or irregular character than on the smaller islands. In the latter, they may be shown to belong generally to a single elevation of igneous origin, or at the most to two or three combined; while in the former, they may pertain to different ranges of hills or mountains. For correct results in any instance, the land and its declivities should be carefully studied beforehand, and the system in its inclinations determined by observation. With regard to Tahiti and Upolu, information bearing upon this point was obtained, and the above conclusions may be received with much confidence. Many of the Feejee reefs, on the same principle, cannot be less than 2000 feet in thickness.

Such accumulations of calcareous rock may appear to be an incredible work for the coral polyp, but only so, because we are not accustomed to contemplate the results which may proceed from the smallest agencies long continued. The operatives in the inorganic world are invisible molecules; and among living organisms, it is the lowest grade, the minims of existence, that have accomplished the grandest results in the earth's history.

ART. XLII.—*On the Infusoria and other Microscopic forms in Dust-showers and Blood-rain;* by Dr. C. G. EHRENBERG.*

THE infusorial character of the dust occasionally transported by winds, is one of the most wonderful of Ehrenberg's discoveries. His investigations have been reported from time to time, since May, 1844, and notices of some of his results have appeared in this Journal. A recent publication, whose title is given below, contains the details of his various researches, with full illustrations. The plates contain not only figures of all the forms observed in each case, but a sketch of a portion of the dust as it

* *Passat-Staub und Blut-Regen*, ein grosses organisches unsichtbares Wirken und Leben in der Atmosphäre; Mehrere Vorträge von Dr. CHRISTIAN GOTTFRIED EHRENBERG, Ord. Prof. d. Medicin und Mitglied und beständ. Secretar der Akad. d. Wiss. zu Berlin, &c. Vorgetragen in der Königl. Preuss. Akad. der Wiss. zu Berlin, vom 23. Mai 1844 bis 1849. Abhandlungen der Akad., 1847. 192 pp. 4to with 6 colored plates, in folio. Berlin, 1849.

lay under the field of his microscope, exhibiting to the eye the relative prevalence of different forms and the colors they presented. The showers, whose microscopic organisms are here reported, are as follows:

I. *In the Atlantic, latitude* 17° 43′ *N., and longitude* 26° *W., about* 500 *miles from the coast of Africa.*—The dust was collected by Mr. Darwin, from the ship in which he was at the time. The direction of the wind was from the African coast. The dust resembled volcanic ashes, although evidently not of this origin, and about a sixth part of it was siliceous shells of fresh water and land infusoria and siliceous phytolites, eighteen species of the former, and as many of the latter. The most of the forms are European, and none exclusively African. Among them there is the South American species *Himantidium papilio*, which occurs at Cayenne, and also a *Surirella*, probably from the same continent. The conclusion follows, as Ehrenberg observes, that either the dust came in part from South America in the upper regions of the atmosphere, or these two species are yet to be discovered elsewhere. A list of the species in this and other showers is given in a following table.

II. *Other dust-showers in the Atlantic, from the collections of Mr. Darwin.*—These collections were made between the years 1834 and 1838, in latitudes 15°, 17°, 19° and 21°, part at San Jago, (Cape Verds) and part within 250 miles of the land in the open sea, between longitudes 22° and 26°. They afford thirty new forms to those of the shower above noticed, and include also the same South American forms, *Himantidium papilio* and *Surirella peruviana.* In addition, there are three species of Eunotia which have been found only in Senegambia and Guiana, together with the *Amphidiscus obtusus*, also South American. Besides the others, there was one Polythalamium, making in all 67 organic forms. The only new species was the *Eunotia longicornis* which is very similar to a Hungarian fossil species. No species peculiarly African was found in the dust; one, the *Lithostylidium Rajula*, occurs at the Isle of France.

III. *Dust which fell at Malta, 15th of May*, 1830.—This dust was obtained by Mr. Darwin from Purser R. G. Didham, of the ship Revenge. The wind at the time was east-southeast, and a similar fall of dust took place at the time, in the bay of Palmas in Sardinia. The number of species afforded was 43, of which 15 were Infusorial, 21 Phytolitharia, and 7 Polythalamia. Some of the species occur in Africa, yet there are no characteristic African forms. And although such showers with the hot winds that attend them, are usually referred to the Sahara desert, they appear to be quite foreign to that region. Among the species, *Synedra entomon* is a characteristic form from Chili. In general character, the species are like those of the Cape Verd and other Atlantic showers.

IV. *Sirocco dust, of Genoa, May* 16, 1846.—In this dust, Ehrenberg found 22 species of Polygastrica, 21 of Phytolitharia, and 3 of parts of plants. The forms have much resemblance to those of the Malta and Atlantic showers. The color is yellowish or ochreous, from oxyd of iron, and not gray like the true African dust, and about $\frac{1}{6}$th to $\frac{1}{5}$d of the mass is organic. None of the species are characteristic African forms, and *Synedra entomon* is South American. This dust was analyzed by Dr. Wolcott Gibbs, who obtained for its composition, excluding the water and organic matter which amounted to 18·53 p. c.,

S̈i	Ä̈l	F̈e	Ṁn	ĊaC̈	Ṁg	K̇	Ṅa	Ċu
45·575	20·547	9·388	4·222	11·648	2·209	3·645	2·332	0·306=100.

The carbonate of lime is from Polythalamia.

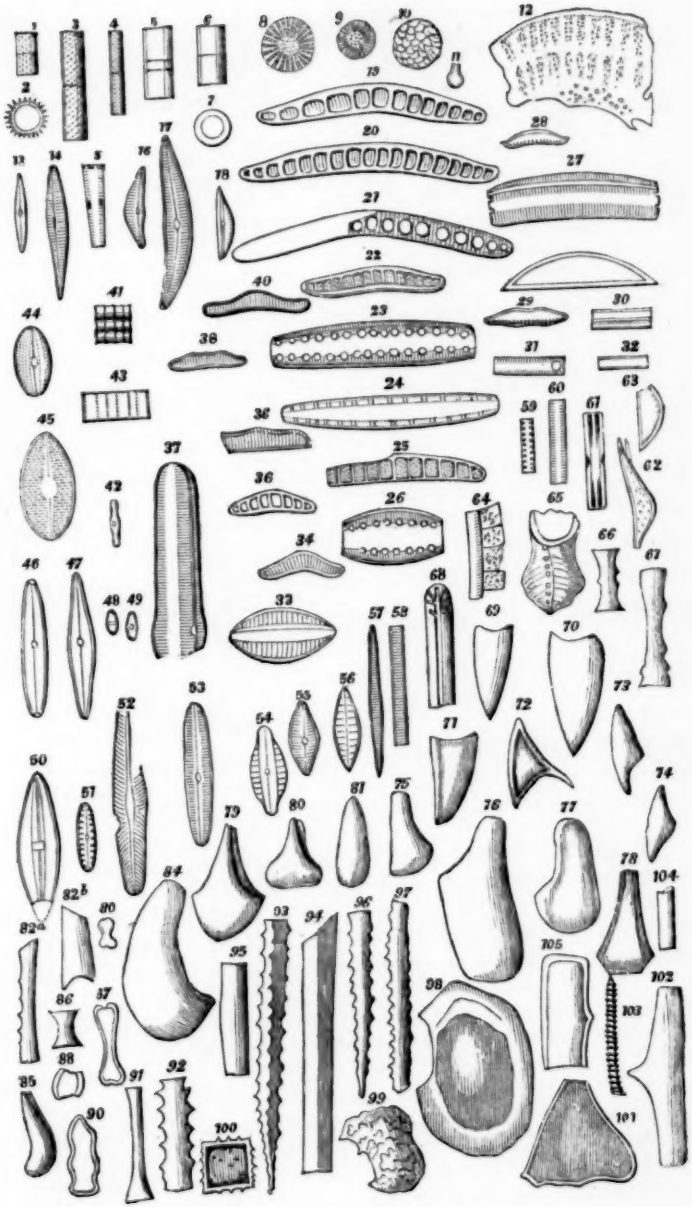
It follows from the preceding results that the showers of the Atlantic, of Malta and of Genoa are in general alike in organic as well as inorganic constitution, *and in the absence of characteristic African forms;* and this resemblance is the more surprising as the observations extend through the long period of 16 years, from 1830, to 1846. They are alike also in the brownish-red color of the dust.

V. *Sirocco dust of Lyons, Oct.* 17, 1846.—The Lyons shower afforded 39 species of Polygastrica, 25 of Phytolitharia, 3 of Polythalamia besides minute portions of plants. The accompanying plate from Plate 5, of Ehrenberg's work, contains 104 out of 123 of his figures, the species of Polythalamia, Spongolithis, and portions of plants being omitted. The species here figured are as follows:*

1. *Polygastrica.*

1, 2, Gallionella granulata.
3 —— decussata.
4 —— procera.
5, 6, 7 —— distans.
8, 9, Discoplea atmospherica.
10, Coscinodiscus?
11, Trachelomonas lævis.
12, Campylodiscus clypeus.
13, 14, 15, Gomphonema gracile.
16, 17, Cocconema cornutum (nec gracile.)
18 —— Lunula.
19, 20, Eunotia longicornis.
21, 22 —— longicornis.
23 —— Argus.
24 —— longicornis.
25 —— granulata?
26 —— zebrina? (Argus?)
27 —— Monodon?
28–32 —— amphioxys (31, *cum ovario*).
33, 34 —— gibberula.
35 —— zebrina?
36 Himantidium zygodon?
37 Eunotia gibba.
38 Eunotia tridentula.
39 Eunotia? lævis.
40 Himantidium Arcus.
41, 42, Tabellaria.
43 Fragilaria pinnata?
44 Cocconeis lineata.
45 —— atmospherica.
46 Navicula Bacillum.
47 —— amphioxys.
48, 49 —— Semen.
50 —— lineolata?
51 Pinnularia borealis.
52 —— viridula.
53 —— viridis.
54 —— tæniata (n. sp.)
55 —— æqualis?
56 Surirella Craticula?
57, 58, Synedra ulna.
59, 60, Fragilaria pinnata?
61 Grammatophora? parallela?
62, 63, Incerti generis (1).
64 Incerti generis (2).
65 Incerti generis (3) (Arcella costata?)

* In copying this plate, the oblique rows of dots on figure 3 are not made quite near enough together, and in fig. 8 the rays are too few in number.



MICROSCOPIC ORGANISMS OF THE LYONS DUST-SHOWER.

2. *Phytolitharia.*

66, 67, Amphidiscus truncatus.
68 —— obtusus.
69–71 Lithodontium furcatum.
72 —— Scorpius.
73, 74 —— rostratum.
75–77 —— Bursa.
78 —— angulosum.
79 —— nasutum.
80 —— triangulatum.
81 Lithostylidium clavatum.
82 *a*, —— Serra.
82 *b*, —— Taurus.
83–85 —— curvatum.
86 —— biconcavum.
87 —— Clepsammideum.
88 Lithosphæridium irregulare.
89 Lithostyldium Clepsammideum.
90 —— crenatum.
91 —— Ossiculum.
92 —— Amphiodon.
93 —— Terebra.
94 —— angulatum.
95 —— rude.
96, 97 —— denticulatum.
98 —— Emblema.
99 —— irregulare.
100 Lithomesites ornatus.
101 Lithostylidium triceros.
102 —— calcaratum.
103 —— spiriferum.
104 —— læve.

In this shower, the organic forms make up about *one-eighth* of the mass. In general character including color, there is a close resemblance to the products of the Atlantic showers and the others above described. The species are nearly all of fresh-water or land origin; one-seventh only are marine species. The most abundant forms of Polygastrica, are *Eunotia amphioxys*, *E. gibberula*, *E. longicornis*, *Gallionella decussata*, *G. granulata*, and *G. procera;* and those of Phytolitharia, *Lithostylidium amphiodon*, *L. ossiculum* and *L. rude.*

There are two South American species, the *Eunotia Pileus* and *Himantidium Zygodon.*

The number of species brought to light from the dust of the nine showers thus far described, is as follows:

Polygastrica 57. Phytolitharia 46. Polythalamia 8.

Besides these, there are seven kinds of particles from plants, and one fragment of an insect. Seventeen of the species are marine, and the other 102 of fresh-water origin. There is no evidence of volcanic origin.

VI. *Second specimen from the Genoa shower of the* 16*th of May*, 1846.—All but one of the forms mentioned were observed in the former specimen of the dust.

VII. *Storm of red snow in Puster Valley in Tyrol, March* 31, 1847.—This red snow owed its color to a colored dust, much resembling that of the Atlantic. Its tint is brownish red.

It afforded, as obtained at two localities, 66 organic forms, 22 of which were Polygastrica, 28 Phytolitharia, 2 Polythalamia, 13 particles of plants, and 1 of an insect. The large majority of the species are known fresh-water and continental forms: only 4 to 6 species are unknown; 2 are marine, namely, *Coscinodiscus radiolatus* and a *Spiroloculina* (?) There is a remarkable resemblance in the color and character of the dust to that of the Atlantic, Genoa and Lyons, and an identity in many of the species. Forty-six species out of the 66 occur in the Sirocco and Atlantic dust. Twelve

Polygastric species and 20 Phytolitharia are common to the Atlantic showers and the Tyrolese snows. This uniformity of character over regions so widely separate, yet in nearly a common latitude or zone, and in so many distinct examples through a number of years, is most surprising.

VIII. *Dust which fell in Italy in* 1803, *and in Calabria in* 1813.—The former of these showers is represented as coming from the southeast. It afforded 49 species, and that of Calabria 64. Out of the 49, 39 have been observed in the more recent showers; and out of the 64, 51 are like the more recent. These showers, although 10 years apart, have 28 species in common, or about one-fourth. In both nearly all the species are of fresh-water or continental origin. In both, as in other showers, the most abundant species are *Eunotia amphioxys*, *Gallionella granulata*, *G. crenata*, *G. distans*, *G. procera*, *Lithodontia*, *Lithostylidia*. In both, also, there are four South American forms; *Coscinodiscus flavicans* from Peru and St. Domingo, *Navicula undosa* from Surinam, *Stauroneis linearis* from Chili and North America, *Synedra Entomon* from Chili. The last occurs also in Africa and Asia. There are no characteristic African species.

Ehrenberg next mentions facts of a similar kind of earlier date. Humboldt when in Paramo, on the way from Bogota to Popayan, at a height of 2300 toises (14,700 feet), observed a red hail, a fact published by him in the Annales de Chimie for 1825. The height of the place gives peculiar interest to the observation.

In 1755, on the 14th of October, at 8 o'clock in the morning, a warm Sirocco wind was blowing at Locarno near Lago Maggiore. At 10 o'clock the air was filled with a red mist, and at 4 o'clock P. M. there was a blood-red rain, which left a reddish deposit, equal to one-ninth of its mass. There fell nine inches of this rain in one night. About 40 square German leagues were covered with this bloody rain, which also extended on the north side of the Alps into Suabia, and nine feet of reddish snow fell upon the Alps. Supposing that the deposit averaged but two lines in depth, there would be for each square English mile, an amount equal to 2700 cubic feet. But actual measurement gave for the depth in some places about one inch (or $\frac{1}{9}$th of 9 inches).

In 1623 there was another blood-rain at Strasburg. It happened on the 12th of August, between the hours of 4 and 5 in the afternoon. In the year 1222 a similar rain fell at Rome for one day and night. Many other like facts are cited.

Ehrenberg favors the view of the atmospheric origin of these showers, and speaks of their relation to the fall of aerolites. Chladni in his work on meteorites observes that the stones which fell between 1790 and 1819, amounted to not less than 600 hundred weight: while for the single dust-shower of Lyons in 1846, the material that fell was full 7200 hundred weight.

The Cape Verd shower had a breadth, according to Darwin,* of more than 1600 miles, and according to Tuckey, of 1800 miles, and extended 6 to 800 miles or even 1000 miles from the African coast. This gives an area of 960,000 to 1,280,000, or from 1,648,000 to 1,854,000 square miles.

The surface of Italy is about 90,000 square miles; that of Sicily 10,000 square miles, making together 100,000. A single dust-shower, covering both countries like that of 1803, to the extent of that of Lyons in 1846, would deposit 112,800 hundred weight of dust in a single day. With such facts before us, Ehrenberg asks, how many thousand millions of hundred weight of microscopic organisms have reached the earth since the period of Homer, the time of our earliest record of such events? He adds, I cannot longer doubt, that there are relations, according to which, living organisms may develop themselves in the atmosphere:—and he speaks of this as a self-development and not a production from introduced ova.† He supposes it probable that the atmospheric dust-cloud region is of vast extent, and is above a height of 14,000 feet. The facts may seem inexplicable on any other hypothesis; yet much more investigation will be required before an opinion so contrary to received principles, can be generally adopted.

The work proceeds with a historical relation of all showers of dust, blood-rain, red snow and similar phenomena, from the earliest records to the present time. This history occupies 100 pages of the volume.

The *first* instance adduced dates about 1500 years before the present era. It is the plague of blood inflicted upon the Egyptians, as related in the Mosaic history, which prevailed throughout the whole land of Egypt, continuing three days and three nights.

The *second* occurred about 1181 B. C., the time of Æneas and Dido, as related by Virgil, Æneid, iv, 454.

> Horrendum dictu, latices nigrescere sacros
> Visaque in obscœnum se vertere vina cruorem.

The *third* about 950 B. C., as described by Homer, Ilias xi, v. 52, 54, and also Ilias xvi, v. 459, 460.

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* Quart. Jour. Geol. Soc., No. 5, 1846, p. 26.

† Ehrenberg observes on page 57:—"Ich darf ferner jetzt kaum mehr zweifeln dafs es Verhältnisse des sich fortentwickelnden Lebens in der Atmosphäre giebt. Diese beiden neuesten Staubarten, welche so höchst massenhaft gefallen sind, tragen die Spur der Existenz und der Fortentwicklung (nicht durch Eibildung, aber durch Selbsttheilung) kieselschaliger Formen zu deutlich. Dennoch kann ich das Verhältnifs, der Phytolitharien und Seethiere halber, welche sich darunter befinden, nicht ein kosmisches nennen. Ich kann mich auch deshalb mit demselben noch nicht ganz befreunden, weil Leben und Fortenwicklung nur bei gleichzeitiger Feuchtigkeit bestehen kann, welche zwar das Leben begünstigt und entwickelt, aber nicht gleichzeitig die rothe Farbe des Staubes und die feinen Pflanzentheile vor Veränderung, Verrotten, schützen kann, was durch Trockenheit sicher erreicht wird. Mischen sich daher zuweilen verschiednartige Verhältnisse?"

The *fourth* about 910 B. C., is the instance of bloody waters mentioned in connection with the victory over the Moabites in 2nd Kings, iii, v, 21, 22, 23.

Ehrenberg mentions then the rain of blood in the time of Romulus, as related by Livy, and goes on with other accounts of subsequent date, with regard to which the information is not of as doubtful character as with those just alluded to.

A supplemental chapter contains a notice of meteoric dust showers since 1846. One on the 31st of March, 1847, in the valley of Gastein, in Salzburg; another in Arabia, Jan. 24, 1848; another in Silesia and Lower Austria, Jan. 31, 1848. The showers afforded similar fresh-water and continental forms, with the same South American species before mentioned, and no characteristic African form. Other showers occurred in 1849. In March there was a reddish dust fell at Catania in Sicily, during a south wind. On the 14th April, during a hail storm in Ireland, there was a black inky deposit, affording numerous microscopic organisms.

The number of showers which Ehrenberg records is in all 340, 81 before Christ and 249 after Christ. These occurred in different centuries as follows:

1. *Before the Christian Era.*

Century.	Showers.	Century.	Showers.	Century.	Showers.
16th	1	5th	4	2nd	28
10th	3	4th	4	1st	18
8th	1	3d	22		

2. *In the Christian Era.*

Century.	Showers.	Century.	Showers.	Century.	Showers.
1st	5	8th	6	15th	6
2nd	1	9th	10	16th	51
3d	2	10th	5	17th	31
4th	4	11th	6	18th	29
5th	2	12th	11	19th	63
6th	10	13th	6		
7th	3	14th	8		

These showers or falls of dust, blood-rain, red snow or the like, occurred in the different months, as far as known, as follows:

January,	27	May,	18	September,	7
February,	14	June,	18	October,	18
March,	23	July,	9	November,	16
April,	18	August,	17	December,	14

From October to March, the winter part of the year, the number is 112, from April to September, the summer part, 87. From January to June the number is 118, and from July to December, 81.

The following is a general view of the periods of recorded showers arranged according to the countries where they occurred.

1. Italy and adjoining Islands.

A. C. 718 710 461 344 295 294 262 223 217 216 215 214
213 212 211 210 209 208 205 203 202 200 194 193
192 191 190 188 184 183 182 181 177 172 169 167
166 163 152 147 143 140 137 136 134 128 126 125
124 118 117 114 111 108 106 102 100 99 98 96
95 94 93 92 91 88 75 53 48 44 42 41
37 30 10.

P, C. 14 54 61 68 70 79 90 202 570 594 746 859
864 1104 1113 1114 1128 1222 1456 1530 1652 1689 1729 1791
1803 1808 1809 1810 1813 1816.

In *Lombardy*.—P. C. 869 874 1510.
In *Sardinia*.—A. C. 217 — P. C. 220.
In *Sicily*.—A. C. 217 — P. C. 559 1803 1849.
In *Malta*.—P. C. 1830.
In *Genoa*.—P. C. 935 1678 1744 1814 1841 1847.

2. Germany (including Holland, Prussia, Austria, and Germanic states.)

P. C. 787 823 839 869 1006 1009 1010 1117 1120 1146 1226 1337
1348 1349 1376 1416 1434 1438 1501 1502 1503 1534 1539 1540
1543 1547 1548 1549 1550 1551 1552 1553 1554 1555 1556 1557
1568 1571 1572 1576 1586 1618 1620 1638 1645 1645 1646 1647
1668 1676 1677 1691 1716 1721 1745 1755 1763 1764 1803 1821
1847 1848 1849.

In *Hungary* 1546, 1848; In *Poland* 1269, 1550.

3. France.

P. C. 434 464 541 581 583 860 1011 1114 1163 1165 1551 1559
1560 1608 1616 1617 1623 1634 1658 1669 1676 1731 1748 1763
1765 1830 1839 1841 1841 1846.

4. Spain and Portugal.

A. C. 75.
P. C. 531 1438? 1531 1551.

5. Greece and European Turkey.

Greece.—A. C. 480 488.—P. C. 1147 1637 1194.
Turkey.—P. C. 266 458 473 512 652 782 860.

6. England, Sweden, Russia.

England.—P. C. 53 570 1274 1755 1849.
Sweden.—P. C. 1319 1529 1629 1711.
Russia.—P. C. 1755 1849?

7. Africa.

A. C. 1577 400 37 35 30 18
1. P. C. 1160 1181 1421 1555 1557 1606 1627 1810 1815 1817 1820 1821
1822 1825 1826 1836 1837 1838 1838 1839 1839 1839 1840 1840
2. *Open sea, in the Atlantic.*
P. C. 1579 (1631) 1668 1683 1692 1719 1812 1816 1830 1833 1834
3. *Cape Verds*.—P. C. 1579 1692 1833.
4. *Canaries*.—P. C. 1683?

8. Asia.

1. *Arabia*.—P. C. 570 1065 1365 1680 1825.
2. *Palestine*.—A. C. 910 332 100;—P. C. 610 1348 1546 1637.
3. *Asia Minor*.—A. C. 950.—P. C. 358 860 897 929 1819.
4. *Persia*.—P. C. 1076.
5. *India*.—P. C. 1680 1815? 1835 1846.
6 *China*.—P. C. 333 811 1334.
7. *Indian Ocean*.—P. C. 1665? 1665 1801? 1815?

9. America.

1. *S. America.*—P. C. 1635? 1680 1737 1799 1802 1812.
2. *N. America.*—P. C. 1741 1780 1785 1814 1843 1843.

10. Australia.

P. C. 1841?

The volume closes with a series of conclusions from the facts mentioned. Ehrenberg remarks that these showers appear to prevail most within a zone extending from the part of the Atlantic off the west coast of Middle and North Africa, along in the direction of the Mediterranean sea, reaching a short distance north of this sea, and continued into Asia between the Caspian sea and the Persian Gulf, perhaps to Turkistan, Kaschgar and China; and they seldom reach north to Sweden and Russia. This zone according to the observations of Tuckey, has a breadth of 1800 miles in the North Torrid zone. The reddish color of the dust as well as the organic forms, show that the dust is not of African origin. Moreover the storm-winds and sirocco are found to afford the same species of organisms.

Ehrenberg repeats again his opinion that these phenomena are not to be traced to mineral material from the earth's surface, nor to revolving masses of dust material in space, nor to atmospheric currents simply: but to some general law connected with the earth's atmosphere according to which there is a self-development within it of living organisms.

The whole number of species of organisms observed is 320. Of marine genera there are only the following: *Coscinodiscus*, *Diploneis*, *Goniothecium*, *Grammatophora*, and *Biddulphia*, besides some Polythalamia and Spongolites. The following are American forms:

Arcella constricta.	Eunotia quaternaria.	Navicula undosa.
Desmogonium Guayanense.	" quinaria.	Stauroneis dilatata.
Eunotia Camelus.	Gomphonema Vibrio.	Suririella Peruana.
" depressa.	Himantidium Papilio.	Synedra Entomon.
" Pileus.	" Zygodon.	Fragmenta incerta—3.

A simultaneous occurrence of dust-showers and falls of meteoric stones, has been observed in probably *eighteen* instances before the Christian era. During the Christian era, *fourteen* coincidences have been observed, making thirty-two in all.

We insert here from this most remarkable work of Ehrenberg the following tables, which present to the eye the range of showers through which the different species of organisms have been observed.*

* The numbers in the table, following the names of the species, refer to the figures of these species on the plate, page 375.

Some of the columns, where there were several for the same shower, have been omitted in copying this table. These omitted columns relate to the storms of 1847 and 1848,—III and IV, in the tables; and any species of these storms not belonging to the columns inserted, are marked by a † instead of an *.

I. Atlantic Dust-showers.—II. Sirocco Dust-showers (in 1813, with meteoric stones).—III. Dust-storm of Tyrol and Saltzburg, 1847.—IV. Winter Dust-hurricane in Silesia and Lower Austria, 1848.—V. Ink-rain, in Great Britain, 1849.

Table I.—Species of Polygastrica.

	I.							II.							III.		IV.	V.
	January, 1833.	March 10, 1834.	March 7, 1838.	March 8, 1838.	March 9, '38. A	March 9, '38. B		Italy, 1803.	Udine, 1803.	Calabria, 1813.	Malta, 1830.	Genoa, 1846. A	Genoa, 1846. B	Lyons, 1846.	Tyrol, 1847.	Salzburg, 1847.	Breslau, 1848.	Ireland, 1849.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
Achnanthes ?	.	.	.	.	.	.	.	*?	.	.	.	.	.					
Amphora libyca,	.	.	.	.	.	.	.	.	.	.	.	.	*					
Arcella constricta,	.	.	.	.	.	.	.	.	.	.	.	.	.			*		
Enchelys (hyalina),	.	.	.	.	.	.	.	.	*									
? costata (65),	.	.	.	.	.	.	*											
vulgaris,	.	.	.	.	.	.	.	.	.	.	.	.	.			†		
Biddulphia ?	.	.	.	.	.	.	.	.	*									
Campylodiscus Clypeus (12),	*	*	*	*	*	*	*	*	*	*	*	*	*		*			
Chætoglena volvocina,	.	*?	.	.	.	.	.	.	.	.	*?							
Chætotyphla ? reticulata,	.	.	.	.	*													
saxipara,	.	.	.	.	.	.	.	.	.	.	*							
Closterium ?	.	.	.	.	.	.	.	.	.	.	.	.	.		†			
Cocconeis atmospherica (45),	.	.	.	.	.	.	.	.	.	.	.	.	*					
finnica,	.	.	.	.	.	.	.	.	*?									
lineata (44),	.	.	.	.	.	.	.	.	.	.	*	.	*					
Cocconema cornutum (16, 17),	.	.	.	.	.	.	.	.	.	.	*	.	*					
Leptoceros,	*?	*	.	.	.	.	*											
Lunula (18),	*	*	.	.	.	.	.	.	.	.	.	*?	*					
Fusidium,	.	.	.	*	.	*	.	*										
lanceolatum,	.	.	.	.	.	.	.	*?										
Coscinodiscus flavicans,	*	.	*?	.	.	.	.	.	*?									
lineatus,	.	.	.	.	.	.	.	.	*?									
radiatus,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*			
radiolatus,	.	.	.	.	.	.	*	.	.	.	.	.	.	*?				
? (minor),	.	.	.	.	.	.	.	.	*									
? (10),	.	.	.	.	.	.	.	.	.	.	.	.	*					
Desmogonium guyanense,	.	*?	.	.	.	.	*?	.	.	.	*?	.	.	.	.	.	†	
Difflugia areolata,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
cellulosa,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
Diploneis didyma,	.	.	.	.	.	.	.	.	.	.	*							
Discoplea atmospherica (8, 9),	*	*	.	*	*	.	*	*	*	*	*	*	*	.	*			
atlantica,	*	*																
?	.	.	.	.	.	.	.	.	.	*?	*?							
?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†		
sinensis ?	.	*	.	.	*	.	.	.	*	.	.	.	.	.	.	.		
Eunotia amphioxys (28–31),	*	*	.	*	*	*	*!	*!	*!	*	*!	*	*!	*	*	*	*!	*
Argus (23),	.	*	*	.	*	.	*	.	*	*	.	*	*	*				
Camelus,	.	.	.	.	*	.	.	.	*?									
depressa,	.	.	.	.	*													
Diodon,	.	.	.	.	.	.	.	.	*	.	*?							
gibba, (37),	*	.	*	*	.	.	*	*	*	*?	.	.	*	.	*			
gibberula (33, 34),	.	*	*	*	*	*	.	*	*	*?	.	.	*					
granulata (25),	.	.	.	.	*?	*?	.	.	*?	.	.	.	*?					
? lævis (39),	.	.	.	.	.	.	.	.	.	.	.	.	*					
longicornis (19–22),	*	.	*	.	*	*	*	.	.	*	.	.	*	*	*			
Monodon (27),	.	.	.	.	.	.	.	.	.	.	*?	.	*?					
Pileus,	*	.	.	.	.	.	.	.	.	.	.	.	*					
quaternaria,	.	*																

Table I.—*Continued.*

	I.						II.						III.		IV.	V.
	January, 1833.	March 10, 1834.	March 7, 1838.	March 8, 1838.	March 9, '38. A	March 9, '38. B	Italy, 1803.	Udine, 1803.	Calabria, 1813.	Malta, 1830.	Genoa, 1846. A	Genoa, 1846. B	Lyons, 1846.	Tyrol, 1847.	Salzburg, 1847.	Breslau, 1848.	Ireland, 1849.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Eunotia quinaria,	.	*	.	.	.	.	.	.	.	.							
Textricula,	.	.	.	.	.	.	.	.	*	*							
tridentula (38),	*?	.	.	.	.	.	.	.	.	.	*	.	*				
Triodon,	*	.	.	*	*	*	.	.	.	.	*	.	.				
Zebra,	.	.	*?	*?	*?	*?	.	.	.	.	.	.	.	.	*?		
zebrina (26? 35?),	.	*	*	*	*	*	*?	*?	*?	.	*	.	*?	*	.		
Fragilaria amphioxys,	.	.	.	.	.	.	*?	.	.	.	.	.	.				
? (Biblarium?)	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	†	
constricta,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
diophthalma,	*	.	.	.	*?	.	.	*?	*	.	.	.	.				
pinnata (43),	*?	.	.	.	*?	*	.	.	.	*	.	.	*?	*	.	†	
rhabdosoma,	.	.	.	*	*	.	.	*?	*	*?	*?	.	.	.	.		
? Synedra,	.	.	.	.	.	.	*	.	*?	.	.	.	.				
Gallionella crenata,	*	*	*	*	*	*	*	*	*	*	*	.	.	*	*		
decussata (3),	.	.	*	*	.	.	*	*	.	*	.	*	*				
distans, (5, 6, 7),	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
ferruginea,	*?	*?	.	*?	*?	*?	*?	*?	*?	.	*?	*?	*?	*?	*?		
granulata (1, 2),	*	*	*	*	*	*	*?	*	*	*	*	*	*	*	*		
laminaris,	.	.	.	.	.	.	*	*	*?	.	.	.	.	*	*		
marchica,	.	.	.	.	*	.	*										
procera (4),	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
tæniata,	.	.	.	*													
Gomphonema clavatum,	.	.	.	.	.	.	.	.	.	.	.	.	*?				
gracile, (13, 14, 15),	*	*	.	.	*?	.	.	*?	.	*?	.	.	*	.	*	†	
longicolle,	.	.	.	.	.	.	.	.	.	.	.	.	*				
rotundatum,	.	.	.	.	*	*?	.	.	*								
truncatum,	.	.	.	.	.	.	.	.	.	.	.	.	.	*			
Vibrio,	.	.	.	.	.	*?											
Goniothecium crenatum,	.	.	.	.	.	.	.	.	.	.	*						
Grammatophora oceanica,	.	*?															
parallela (61?),	.	*?	.	.	.	.	.	.	.	.	.	.	*?				
Himantidium Arcus (40),	*	*	.	*?	*	.	.	.	*	.	*?	.	*				
gracile,	*	.	*														
Papilio,	.	*?	.	.	*												
Zygodon (36?),	.	.	.	.	.	.	.	.	.	.	.	.	*				
Meridion vernale,	.	.	.	.	.	.	*										
Monas viridis,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*?
Navicula affinis,	*	*	.	.	*	.	.	.	.	.	*	.	*				
amphioxys (47),	.	.	.	.	.	.	.	.	.	.	.	.	*				
Bacillum (46),	.	*	.	.	*?	.	.	.	.	*	.	.	*?				
dubia,	.	.	.	.	.	.	*										
emarginata,	.	.	.	.	.	.	.	.	*								
fulva,	.	.	*	.	.	.	.	.	*								
gracilis,	.	.	.	.	.	*	.	.	.	.	*						
lineolata (50?),	*	.	.	*	*?	.	.	.	*	.	.	.	*				
Scalprum,	.	.	.	.	.	.	*										
Semen (48, 49,),	.	.	.	.	*	.	*	.	*	.	*	.	*?	.	*	†	*
undosa,	.	.	.	.	.	.	.	.	*								
?	.	.	.	.	.	.	.	.	.	.	.	*					
?	.	.	.	.	.	.	.	.	.	.	.	.					
Pinnularia æqualis (55?)	*	*	.	*	*	*?	.	.	.	.	.	.	*	*			
affinis,	.	*	.	.	.	.	.	.	.	.	.	.	.	.	†		

Table I.—*Continued.*

	I.						II.							III.		IV.	V.
	January, 1833.	March 10, 1834.	March 7, 1838.	March 8, 1838.	March 9, ?38. A	March 9, ?38. B	Italy, 1803.	Udine, 1803.	Calabria, 1813.	Malta, 1830.	Genoa, 1846. A	Genoa, 1846. B	Lyons, 1846.	Tyrol, 1847.	Salzburg, 1847.	Breslau, 1848.	Ireland, 1849.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Pinnularia amphioxys,	.	*															
borealis (51)	.	*	.	*	*	.	.	*?	*	.	*	.	*	*	*	*	
gibba,	.	.	.	.	*												
nobilis,	.	.	.	.	.						*						
tæniata (54),	.	.	.	.	.						.	.	*	*			
Termes,	.	.	.	.	.						*						
viridis (53),	*?	*	.	*	*	.	*?	.	*	.	.	.	*	.	*?	†	
viridula (52),	*	*	.	*	*	*?	.	.	.	.	.	.	*	*	†		
?	.	.	.	.	.		.	.	.	.	.	.	.	*			
? (Amphora ?).	.	.	.	.	.		.	.	.	.	.	.	.	.	.	†	
Podosphenia Pupula,	.	.	.	.	.		.	.	.	.	.	.	.	.	*		
Pyxidicula (Coscinodiscus ?),	.	.	.	.	.		*?										
Spirillum Undula,	.	.	.	.	.		.	.	.	.	.	.	.	.		.	*!
Stauroneis dilatata,	*																
Legumen,	.	.	.	.	.		.	.	*								
linearis,	.	.	.	.	.		.	.	*								
Phœnicenteron,	.	*	*														
Semen,	.	.	.	.	.		.	.	.	.	*?	.	.	*			
Stauroptera cardinalis,	.	.	.	.	.		*?	.	*								
parva,	.	*															
Staurosira construens,	.	.	.	.	.		.	.	*								
Surirella Craticula (56?),	.	.	.	.	.		.	.	*	.	*	.	*?	*			
? Entomon,	.	.	.	.	.		.	.	*								
? paradoxa,	.	.	.	.	.		.	.	*								
peruana,	.	.	.	.	*?												
undulata,	.	*?	.	.	.		.	*?									
Synedra capitata,	.	*															
Entomon,	.	*	.	*	.	*?	*!	*!	*!	*?	*	*	.	.	*	*	
Ulna, (57, 58),	*	*	*	.	*?	*	*	*	*	*	*	.	*	*	*	†	*
?	.	.	.	.	.		.	.	.	.	.	.	.	.	.	†	
?	.	*															
Tabellaria ? (41, 42),	.	.	.	.	.		.	.	.	.	*?						
?	.	.	.	.	.		.	.	.	.	.	.	*				
Trachelomonas lævis (11),	.	*	.	.	*?		.	.	.	.	.	.	*	.	†	†	
Fragmenta incertæ, 1	.	.	.	.	.		.	.	.	.	.	.	*				
Fragmenta incertæ, 2	.	.	.	.	.		.	.	.	.	.	.	*				
originis, 3	.	.	.	.	.		.	.	.	.	.	.	*				
	137	29	40	17	24	39	22	28	26	46	19	35	12	48§	20	19	4§	5

§ The number of species from the specimen of dust of this storm collected at Hirschberg, was 8; and from Niesky, 10.

Table II.—Phytolitharia, Polythalamia, etc.

	I.							II.							III.		IV.	V.
	January, 1833.	March 10, 1834.	March 7, 1838.	March 8, 1838.	March 9, '38. A	March 9, '38. B		Italy, 1803.	Udine, 1803.	Calabria, 1813.	Malta, 1830.	Genoa, 1846. A	Genoa, 1846. B	Lyons, 1846.	Tyrol, 1847.	Salzburg, 1847.	Breslau, 1848.	Ireland, 1849.
PHYTOLITHARIA.	1	2	3	4	5	6		7	8	9	10	11	12	13	14	15	16	17
Amphidiscus armatus,	.	.	*?	.	*	.		.	.	.	.	.	*					
clavatus,	.	.	.	*	*	.		.	.	.	*	*						
fistulosus,	.	.	.	.	*			.	.	.	.							
Martii,	.	.	*	.								*						
obtusus (68),	*	*	.	*	*	*		.	.	.	*	*	.	*	*	†		
Rotella,	.	*	.	.	.	.		*										
Rotula,	.	.	*															
truncatus (66, 67),	*	*	*	*	*	.		*	*	*	*	*	.	*	*	*	*	
Assula (*silicea*?§) hexagon.																		
umbonata,	.	.	*	.	.	.		*	.	.	.	.	.	.	.			
Lithasceriscus tuberculatus,	.	.	.	.	.	.		.	*	.	*	*	.	.	.	*	*	
Lithochæta lævis,	.	.	.	*	.	.		.	.	.	.	.	.	.	†	.	†	
Lithodontium angulosum (78),	.	.	.	.	.	.		.	.	.	.	.	.	*				
Bursa (75–77),	.	.	*	*	*	*		*	.	*	*	*	.	*	*	†	†	*
curvatum,	.	.	*	.	*	*		*	.	*	*	.	.	*	.	†	†	
excisum,	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	†	
falcatum,	.	.	.	.	.	.		*?	.	.	.	.	.	.	*			
furcatum (69–71),	.	*	*	*	*	*		*	.	*	*	*	.	*	*	*	*	*
nasutum (79),	.	.	*	*	*	*		.	.	*	*	*	.	*	*	*	*	
obtusum,	.	.	.	.	.	.		*?	.	.	.	.	.	.	.	.	*	
platyodon,	.	.	.	*	*	.		.	.	*	.	.	*	*	†	.	*	
rostratum (73, 74),	*	*	*	*	*	*		*	.	*	*	*	*	*	*	†	*	*
Scorpius (72),	.	.	.	.	.	.		*	.	.	.	*	.	*	.	.	*	
triangulum (80),	.	.	.	.	.	.		.	.	.	.	.	.	*	.	.	*	
truncatum,	.	.	.	.	*													
Lithomesites ornatus (100),	.	.	.	.	.	.		.	.	.	.	.	.	.	.	*	†	
Pecten,	.	.	.	.	.	.		.	.	.	.	*	.	*				
Lithostomatium ellipticum,	*																	
Rhombus,	.	.	.	.	.	.		.	.	*	.	*						
Lithosphæridium irregulare,	.	*						*				*			†			
Lithostylidium Amphiacanthus,	.	.	.	.	*	*												
Amphiodon (92),	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*
angulatum (94),	.	*	.	.	.	.		.	.	.	.	.	.	*	.	*	*	
articulatum,	.	.	.	.	*										†			
biconcavum (86),	.	*?	*	*	*	*		*	.	*	*	*	*	*	*	*	*	
calcaratum (102),	.	.	*	.	*	*		*	.	.	*	.	.	*	.	*	*	
Cassis,	.	.	.	.	.	.		.	.	*								
Catena,	.	.	.	.	.	.		.	.	.	.	.	.	.				
clavatum (81)	.	*	*	*	*	.		*	.	.	*	*	.	*	†	†	†	
Clepsammidium (87)	*	*	*	*	*	*		*	.	.	*	*	*	*	*	.	*	*
comptum,	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	†	
crenulatum (90),	.	*	.	*	.	.		.	*	.	*	*	.	*	†	*	†	
curvatum (83–85),	.	.	*	.	.	.		.	.	.	*	*	.	*	.	†		
denticulatum. (96,97)	.	*	.	.	*	.		*	.	*	*	*	.	*	*	*		
Emblema, (98?)	.	.	*	.	.	.		.	.	.	*	.	.	*	†	.	†	
falcatum,	.	.	.	*	.	.		.	.	.	.	*	.	.	.	*		
Fibula,	.	.	.	.	.	.		*	.	*	.	.	.	.	.	.	*	
Formica,	.	*	.	.	.	.		*	.	*	*	.	.	.	.	.	†	

§ Not dissolved in acids.

Table II.—*Continued.*

	I.						II.						III.	IV.	V.
	January, 1833.	March 10, 1834.	March 7, 1838.	March 8, 1838.	March 9, '38. A	March 9, '38. B	Italy, 1803.	Udine, 1803.	Calabria, 1813.	Malta, 1830.	Genoa, 1846. A	Genoa, 1846. B	Lyons, 1846.	Tyrol, 1847.	Salzburg, 1847.	Breslau, 1848.	Ireland, 1849.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Lithostylidium irregulare (99),	.	.	*	*	.	*	.	.	*	.	.	.	*	*	.	†	
læve (104),	.	.	.	*	*	*	.	.	*?	*	.	.	*	*	.	†	*
Lima,	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.		
obliquum,	.	*	*	*	.	.	*	.	.	*	*	.	.	.	.	†	
Ossiculum (91),	.	.	.	.	*	.	*	.	.	*	*	.	*	.	.		
polyhedrum	.	.	.	.	.	.	.	*	.	.	.	.	.	*	*	†	
quadratum,	.	*	*	*	*	*	*	.	*	*	*	*	*	*	*	*	*
Rajula,	.	.	*	.	.	.	.	.	.	*	.	.	.	*	.	†	
Rectangulum,	.	.	.	.	.	*	*	.	*	*	.	.	.	†	.		
Rhombus,	.	.	*	.	.	.	.	.	.	.	*	.	.	.	.	†	
rostratum,	.	.	.	*	.	.	.	.	.	.	.	.	*	†	.	†	
rude (95),	.	*	*	.	*	*	*	.	*	*	*	*	*	*	*	*	*
Securis,	.	.	*	.	.	*	.	.	*	*	.	.	.	*			
serpentinum,	.	.	.	.	.	.	*	.	*	.	.	.	*	†	.	*	
Serra (82 *a*),	*	*	*	*	*?	*	*	.	*	*	*	.	*	*	†	*	
sinuosum,	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.		
spinulosum,	.	.	*	.	.	.	.	.	*	.	.	.	*	.	.	†	*
spiriferum (103),	.	.	.	.	*	.	*	.	*	.	*	.	*	*	*	†	
Taurus (82 *b*),	.	.	*	.	*	.	*?	.	.	*	.	.	*?	†	†	*?	
Terebra (93),	.	.	.	.	.	.	.	.	.	.	.	.	*	*			
Trabecula,	.	*	*	*	.	.	*	.	*	*	.	*	*	.	*	*	*
Triceros (101 ?)	.	.	*	*?	.	.	.	.	*	*	.	.	*?	†			
undatum,	.	.	*														
unidentatum,	.	.	*?	*	.	*	.	.	.	*	*	*	*	*	.	†	
ventricosum,	.	*	.	.	.	*	.	.	*	.	.	.	.	.	*	†	
?																	
Spongolithis acicularis,	.	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
amphioxys,	.	.	.	.	*												
apiculata,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*		
aspera,	*	.	.	.	.	*	*										
Caput Serpentis,	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	†	
cenocephala,	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	†	
Clavus,	.	.	.	.	.	.	.	.	.	*							
fistulosa,	*?	.	.	.	.	.	.	.	*	*	.	.	.	.	.		
foraminosa,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	
Fustis,	.	.	*?	*?	.	*?	.	.	.	*	*	.	*	.	.	†	
inflexa,	.	.	.	.	.	.	.	.	.	*							
mesogongyla,	.	.	*	*	*												
obtusa,	.	.	*	.	*	*	*	.	.	.	.	.	.	*	*		
philippensis,	.	.	.	.	.	.	.	.	.	*							
robusta,	.	*	*	.	.	*	.	.	.	.	.	.	.	.	.	*	
? (obtusa aspera),	.	.	*	.	.	.	.	.	*								
Triceros,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
POLYTHALAMIA.																	
Grammostomum ?	.	.	.	.	.	.	.	.	.	*?							
carinatum,	.	.	.	.	.	.	.	.	.	*?							
	.	.	.	.	.	.	.	.	.	.	.	.	.		†		
Miliola,	.	.	.	.	.	.	.	.	*?	.	.	.	.	*?			
Nodosaria,	.	.	.	.	.	.	.	.	.	.	.	.	*				
Planulina,	.	.	.	.	.	.	.	.	.	*?							

Table II.—*Continued.*

	I.						II.						III.		IV.	V.
	January, 1833.	March 10, 1834.	March 7, 1838.	March 8, 1838.	March 9, '38. A|B		Italy, 1803.	Udine, 1803.	Calabria, 1813.	Malta, 1830.	Genoa, 1846. A|B		Lyons, 1846.	Tyrol, 1847.	Salzburg, 1847.	Breslau, 1848.	Ireland, 1849.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Rotalia globulosa,	.	.	.	.	.	.	*?	.	.	*	.	.	.	.	.	.	*
senaria,	.	.	.	.	.	.	*?	.	.	*	.	.	.	.	.	.	
?	.	.	.	.	.	.	.	.	.	*	.	.	.				
?	.	.	.	.	.	.	.	.	.	.	.	.	*				
Spirillina,	.	.	.	.	.	.	.	.	.	*	.	.	.				
Spiro-loculina ?	.	.	.	.	.	.	*	.	.	*?	.	.	.	*			
?	.	.	.	.	.	.	.	.	.	.	.	.	*	†			
Textilaria globulosa,	.	.	*?	.	.	.	.	.	.	*	.	.	*	.	.	†	*
striata,	.	.	.	.	.	.	.	.	.	*?	.	.	.				
? Fragmentum,	.	.	.	.	.	.	*	.	.	.	.	.	.				
?	.	.	.	.	.	*	.	.	.	.	.	.	.				
?	.	.	.	.	*	*	.	.	*	.	.	.	*				
?	.	*	*	.	.	.	.	.	.	.	.	.	.				
PLANTARUM PARTIC. MOLLES.																	
Seminulum reniforme læve,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
tuberculosum,	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	†	
triticei forma,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
constrictum costatum,	.	.	.	.	.	.	.	.	*	.	.	.	.				
ovatum acutum,	.	.	.	.	.	.	.	.	.	.	*	.	.				
Filicis,	.	.	.	.	.	.	.	.	.	.	.	.	.	†			
(Fungi?) ovatum obtusum,	*	*															
Sporangia (Fungorum?)																	
disperma,	*																
trisperma,	*	.	.	.	.	.	.	*	.	.	.	.	.	.	.	*	
4sperma,	.	.	.	*	.	.	.	.	*	.	.	.	*	.	.	†	
5sperma,	.	.	.	.	.	.	.	.	.	.	*	.	*			†	
6sperma,	.	.	.	.	.	.	.	.	.	.	*	.	*	.	.		
Phragmidii ?	.	.	.	.	.	.	.	.	.	.	*	.	*				
Epidermis plantæ,	.	.	.	.	*	.	.	.	.	.	.	.	.	*	*	.	*
Parenchymaticæ cellulæ,	.	.	.	.	*	.	.	*	.	.	.	*	*	*	.	†	*
Prosenchymaticæ cellulæ,	.	.	.	.	.	.	.	*	.	.	.	.	.				
Cellulæ liberæ,																	
subglobosæ læves,																	
oblongæ læves,																	
dentatæ,																	
Fibra plantæ nodosa,	.	.	.	.	.	.	.	.	*	.	.	.	.	*			
spiralis,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*
fibrosa,	*	.	*	*	.	.	*	.	.	.	.	.	.	*	†	†	*
reticulata,	.	.	.	.	.	.	.	.	.	.	.	.	.	†	†	†	
porosa,	.	.	.	.	.	.	.	.	.	.	.	.	.	†			
ocellata (Pini),	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	†	
Denticulus folii marginalis,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
Pilus plantæ simplex lævis,	.	.	.	.	.	.	.	*	*	.	.	*	*	*	†	†	
asper,	.	.	.	.	.	.	.	.	*	.	.	.	*	†	*		
tugidus lævis,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
asper,	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.		
apice spiralis,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
inflexus,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
basi turgidus,	.	.	.	.	.	.	*	.	.	*	.	.	.	*			
constrictus,	.	.	.	.	.	.	.	.	*	.	.	.	.	*			

Table II.—*Continued.*

	I.						II.							III.		IV.	V.
	January, 1833.	March 10, 1834.	March 7, 1838.	March 8, 1838.	March 9, '38. A	March 9, '38. B	Italy, 1803.	Udine, 1803.	Calabria, 1813.	Malta, 1830.	Genoa, 1846. A	Genoa, 1846. B	Lyons, 1846.	Tyrol, 1847.	Salzburg, 1847.	Breslau, 1848.	Ireland, 1849.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Pilus articulatus lævis acutus,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
obtusus,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
asper,	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.		
fasciculatus,	.	.	.	.	.	.	.	.	.	.	*	.	.	.	*		
ornithorhamphus,	.	.	.	*	.	.	.	.	*	.	*	.	.	*	.		
hamatus,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
dentatus,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
stellatus dichot.,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
Squamula plantæ radiata,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.		
	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.		
Pollen ? tricoccum,	.	.	.	.	.	.	.	.	.	.	*	*	.	.	*		
? flexuosum,	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.		
? triquetrum,	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.		
Pini maius,	.	.	.	.	.	.	.	.	.	.	.	.	*	.	*	†	
minus,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
Musci frondosi particulæ,	.	*	.	.	.	.	.	.	*?	.	.	.	.	.	.	†	
Conferva tenuissima,	.	.	.	.	.	.	*!	.	.	.	.	.	.	.	.	†	*!
?	.	.	.	.	.	*	.	.	*	.	.	.	.	.	.	.	
Ulva,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*!
Particulæ incertæ,	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.		
	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.		
INSECTORUM FRAGMENTA.																	
Antenna (Palpus ?),	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.		
Pes,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
Lepidopteri alæ squamula,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
integra,	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	†	
alia,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
5dentata,	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	†	
3dentata,	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.		
Ala Dipteri,	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	†	
ANORGANICA.																	
Crystalli columnares.																	
alliaceo virides,	*	.	*	.	.	.	*	*	*	*	*	.	*	*	*	*	
pallide virides,	*	*	.	.	.	.	.	.	.	.	.	.	.	.	*	*	
hexagoni regulares,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
albi,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
Sem. Tritici forma,	.	*	.	*	.	.	*	.	*	.	*	.	*	.	†		
rubri,	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.		
aurantiaci,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
cubici albi (Spathi),	.	.	.	.	.	.	.	.	.	.	.	.	.	*	†	†	
rhomb. albi (Spathi),	*	*	.	.	.	.	.	*	.	*	*	.	.	*	†	†	
Pumiceæ particulæ,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
Arena quartzea,	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
184	17	29	43	33	37	31	43	15	50	54	48	16	58	44	32	36	20

ART. XLIII.—*Notice of the Geology of the Florida Keys, and of the Southern Coast of Florida;* by M. TUOMEY, Prof. Geol., University of Alabama.

DURING the past summer, I paid a short visit to the coast of Florida, with the view of comparing the recent deposits there, with the white limestone of Alabama. This limestone occurs in the latter state in a stratum two or three hundred feet in thickness, composed for the most part of irregular grains of carbonate of lime, sometimes but slightly cohering, but frequently sufficiently hard to fit it for a building material. It abounds in fragments of corals, but the most conspicuous fossil, on account of the vast numbers in which it occurs, is Orbitoides Mantelli. This fossil, so far as I know, is not found east of Alabama, and certainly does not extend into South Carolina. Echinoderms and corals are found in great abundance wherever the white limestone occurs. It has been traced from Mississippi to the Cape Fear river above Wilmington; throughout the entire distance, whilst the stratum varies in thickness, its mineral composition continues unchanged—a white and nearly pure carbonate of lime. Towards Virginia it becomes more siliceous, the corals and echinoderms disappear, but the other fossils for the most part are identical.

Some specimens of white calcareous mud from Florida, which I saw in the cabinet of my friend, Prof. Gibbes, of Charleston, and which, when dried, presented nearly the same appearance as the white limestone, lead me to suppose that there exists, at this moment, in the Gulf of Mexico, conditions similar to those under which the tertiary white limestone was deposited.

The recent limestone from the West India Islands, so frequently brought as ballast by vessels, is seen on all our wharves, and is familiar to every one; but I did not know till I reached Key West, that at all the Keys between that and Key Biscayne, the sands on the shore, and the very mud on the bottom of the sea of that region were all calcareous—without even a particle of anything siliceous.

Key West is about six miles in length and two miles wide, the highest point being fifteen or twenty feet above mean tide. The deepest wells are about fifteen feet in depth; the water in them which is slightly brackish, ebbs and flows with the tide. The explanation of this phenomenon, which is often seen in the wells sunk in the porous strata along our coast, is doubtless found in the fact that the water of the wells is backed up by that of the tide, upon which it floats as we see in our rivers. The rock perforated in these wells, like that everywhere else exposed, is sufficiently soft to yield readily to the axe, with the exception of a thin crust of a few inches on the surface which is

quite hard, especially where it is exposed alternately to the action of the tides and atmosphere. This indurated crust may be seen on the road between the town and the barracks, and around the salt-works. Below this crust the rock is quite soft, and in some other respects resembles the Alabama white limestone; but the most striking difference, next to that of organic remains, consists in the distinctly oolite structure of the Florida limestone. This structure is seen where one would be led to expect it, in the fine-grained seams. A few hundred yards from the hospital a quarry has been opened where the rock may be examined. The organic remains consist of broken shells and water-worn fragments of corals, which, both in species and state of preservation, resemble those on the shores of the island. Except in degree of hardness, the rock does not differ from the calcareous sands thrown up by the waves on the shore in the vicinity; and the conditions presented by the loose moving sands, are not favorable to the habits of molluscous animals, nor are fossil shells very abundant in the limestone of the island. Oblique or false stratification is everywhere seen in the rock, the inclination of the planes differing very little from the slope of the shore up which the waves push dead shells, pieces of coral, &c. After a breeze, coarse materials are found strewing the beach, a light wind leaves a finer deposit, and in the succeeding calm the sea appears milky from fine calcareous matter suspended in the water; this is deposited in the form of free impalpable mud which invests marine plants and other objects, to which it adheres with great tenacity, and becomes a source of annoyance to collectors of Algæ. All these alternations of fine and coarse materials may be observed in the limestone.

Along the south beach, the sand is thrown up by the waves to an elevation nearly equal to that of the highest point of the island, and during the gale of Oct. 1841, the greater part of it was submerged, so that, at first sight, it might appear that the whole island was the result of sand thrown up at such times. But although I observed no beds in the limestone that prove, like those of our tertiary, that the animals whose remains they contain, lived and died on the spot, yet in its structure it shows the result of long continued steady wave-work, that cannot be referred to any such cause. There are, however, on other parts of the coast, evidences of gradual elevatory movements.

On Key West I found in the rocks, no beds of corals retaining their original position, although large fragments are scattered through the mass. Living corals of two or three genera are abundant in the surrounding shallow water.

Some of the small Keys, such as the Mangrove Keys, are the result of gradual deposition of sedimentary matter, many of those interspersed among the larger islands have not yet reached the

level of high water, but are nevertheless covered by a dense growth of this curious tree. It would be difficult to imagine a plant better adapted to island making, than the Mangrove. Its long pendulous seeds fall into the shallow water, stick in the soft mud and take root; the bud proceeding from the opposite extremity, soon shoots up above water and sends down branches almost perpendicularly into the mud, these take root and produce other trees, and so on. Besides these, lateral shoots are given off, and at a distance of three or four feet, enter the water and take root; from the part above water others proceed and take a similar stride, and in this way they often travel twenty or thirty yards from the parent stem. Seaweeds and drift-wood become entangled among the stems, and very soon a permanent island is formed. Such islands are generally found under the lee of the Keys.

But the greater number, if not all, the Keys rest upon a foundation of corals. At Sand Key, large rugged masses of dead coral are seen bordering the Key on the windward side, and rising above low water; similar masses may be seen at Sambo Key and at other places along the outer reef. But the Keys within this barrier present better opportunities for studying the foundation upon which they rest. At Key Vacca corals rise to a height of four feet above high water, and present not the slightest evidence of disturbance, beyond the upward movement which raised them to their present position. The rocky mass of coral along the margin of the Key is undermined by the waves, and otherwise worn into singularly rugged shapes, with sharp projecting points. Even at some distance from the water, bunches of coral project above the surface wherever the overlying sand is washed away.

On Bahia-honda similar appearances are presented, where the coral rocks extend seaward; on the lee of the island, a long sandbank is thrown up, and a lagoon of considerable extent is formed, in which the mangrove tree is seen striding about in the soft mud. This island was washed in two by the last hurricane, and the channel formed has three feet of water at low tide. In the shallow water off many of the Keys, very beautiful patches of algæ interspersed with living corals, are seen within six or eight inches of the surface. Off Indian and Plantation Keys, dark knobs of coral are visible upon the white mud of the bottom, which render the navigation amongst these keys dangerous. On Lower Matacumba I traced the rugged coral rocks for a mile in extent; I also found them on Conch Key, as I did indeed on nearly every island that I examined, where a section could be found on the shore, from which the overlying sands were washed.

There can be no doubt that this great chain of Keys diverging from Key Biscayne, extending over a distance of one hundred and fifty miles, and having an average breadth of fifteen miles, is

due to the elevation of a vast uneven coral reef whose prominent points rising above the water, form the foundation of the Keys, the sands driven up by the waves having done the rest.

The water between the reef and main land is in many places shallow; the bottom is covered with white calcareous sand and soft mud, and is intersected by tortuous channels. The first siliceous sand that I saw, was dredged up off Soldier Key; from this point it was traced, on the bottom, to Cape Florida, and beyond this towards the north it covers the Atlantic shore.

The adaptation of the Keys and adjoining coast to the production of tropical fruits, is well known in the streets of Key West; the cocoa-nut tree ripens its fruit, yet the absence of soil is quite remarkable; I did not see two acres of land having a depth of soil of three inches, on any of the islands that I visited.

Besides Key West, very few of the Keys are inhabited, so that it was not a little cheering to come upon the stations and signals of the Coast Survey, although operations were suspended at that season.

After examining the limestone of Tampa bay, which I think Mr. Conrad has correctly referred to a tertiary formation older than the miocene, I did not expect to find the main land at the mouth of the Miami made up of beds of limestone of the same age as those I examined at Key West and elsewhere inside the reef. The fossils are all identical with the shells living in the surrounding water.* On both sides of the mouth of the river near Fort Dallas, I found fossils showing on the weathered surface of the rocks; and among them Lucina Jamaicensis, and Pyrula perversa. Like that of Key West, the rock has the appearance of having resulted from sands washed up by the waves.

The Miami is one of the outlets of that vast swamp, the 'Everglades,' it has found a passage through the crescent-shaped dam of limestone which encloses and causes that extraordinary morass. It is about three miles and a half to the first falls where the river emerges from the 'Everglades;' a short rapid is formed, upon which a mill is placed for the manufacture of arrow-root from Coomty, (*Zamia integrifolia,*) a plant that grows abundantly on the ridge surrounding the Glades. The section presented at the falls in every respect resembles that at the mouth of the river, and it is known that the 'Everglades' rest on a vast basin of this limestone. Judging by the eye alone, the ridge through which the Miami flows must be twenty or thirty feet in height; while the Glades are said to be but six or eight feet above tide.

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* This fact had been previously pointed out by B. Smith, Esq., in a report to the Secretary of the Treasury in 1848, which I saw after these observations were made.

It seems strange that while so much speculation has been excited in relation to the drainage of this swamp, so few lines of levels have been seen, the only means after all, of settling this important question.

The soil on the margin of the 'Everglades' is composed of vegetable matter and white silicious sand which seems to be washed in by the rains from the ridges.*

The best point for the examination of the limestone of the main land, is at Lewis's Point, a short distance from the mouth of the river; the section is about twelve feet in height, and in a few hundred yards all the characteristics of the limestone are finely presented.

It was curious to observe at this locality the influence of the river on the mollusca. The only oysters that I observed occur here. I found also a Perna, which I do not find recorded among the marine fauna of our coast, although the genus occurs fossil in Virginia and Maryland.

In a limestone so porous and soft as this, the existence of lime-sinks, subterranean streams and natural bridges is not surprising.

What portion of the Peninsula is made up of this very recent formation, I am unable to say, but as I have already stated, it must not be confounded with the tertiary of Tampa which doubtless extends to Charlotte harbor.

The contour of the ridge surrounding the 'Everglades,' taken together with the structure of the rock of which it is composed, and imbedded organic remains, leads very strongly to the conclusion that it once occupied a position similar to that now occupied by the Keys. And it is evident that an elevation of the Keys of about ten or twenty feet would produce a similar ridge, shutting out the sea from the space, at present, between the reef and the main land, and producing a second 'Everglade,' differing from the present only in its greater comparative length.

Tuskaloosa, Feb. 26th, 1851.

Art. XLIV.—*On the Law of the Rotation of the Primary Planets;* by Daniel Kirkwood.

In the American Journal of Science and Arts, for March, 1851, I notice an article by Prof. Loomis, calling in question the truth of the recently discovered analogy in the periods of rotation of the primary planets. The reasons assigned by Professor Loomis for withholding his assent to this law are:—

I. That it gives an improbable period of rotation to Uranus.

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* I have but recently received the species collected, and have therefore had no time for examining them.

II. That the mass, distance and time of rotation of the original planet between Mars and Jupiter, as determined by the law in question, are inadmissible.

III. That the values of the rotation constant for Mars, Jupiter and Saturn are not identical; and

Finally, that the law is incompatible with certain analogies found to exist between the different members of our planetary system. I design in this paper briefly to review these objections in order. The first has the greatest appearance of plausibility, and is therefore entitled to special consideration.

The time of rotation of Uranus, according to my analogy, is about 34 hours. Professor Loomis, on several accounts, regards this period as inadmissible. His first objection is stated as follows:

"Laplace, in the Mec. Cel., vol. iv, p. 356, says, 'the time of rotation of Uranus is not probably much less than that of Jupiter or Saturn,' and in the last edition of Herschel's Astronomy, page 648, the time of rotation is given at 9h. 30m.?"

To this I reply, that Uranus's time of rotation *has never been measured.* Consequently if the first objection is different from the second it has no other foundation than mere conjecture.

The second objection is based on Mädler's determination of the planet's polar compression. But can its rotary velocity be deduced from its figure? Exclusive of Uranus, the oblateness of only four members of our system has been measured: viz., the Earth, Mars, Jupiter and Saturn. The figure of Saturn, it is well known, is not that of a regular spheroid. It was observed by Sir William Herschel that "the flattening of the poles did not seem to begin till near a very high latitude, so that the real figure of the planet resembled a square, or rather a parallelogram with the corners rounded off deeply, but not so much as to bring it to a spheroid." The proportion of the disc, as given by Herschel is

Diameter of the greatest curvature, .	36
Equatorial diameter, ...	35
Polar diameter, ...	32

This figure, it is evident, could not have been produced simply by the centrifugal force due to the planet's rotation. Again, the oblateness of Mars is, according to Arago, eight times, or according to Herschel, nineteen times greater than that of the figure of equilibrium of a fluid having the same variation of density as the earth. In other words, Arago's determination of this planet's polar compression indicates a rotation-period of less than nine hours; Herschel's measurement, less than six hours; and a mean between the two, about seven hours. The true period, therefore, exceeds that inferred from the shape of the planet in about the same proportion as my estimate of Uranus' period

exceeds that of Prof. Loomis. "The singular irregularities in the form of Saturn, and the great compression of Mars," says a distinguished writer, "prove the internal structure of these two planets to be very far from uniform."

While, then, the compression of a planet may be regarded as denoting in general the *fact* of its rotation, it is by no means a reliable indication of its angular velocity. In all probability, a variety of modifying causes, which cannot at present be reached by our analysis, have coöperated in producing the actual forms of the heavenly bodies.

If the planets have undergone a progressive contraction from a state of vapor, their oblateness at former epochs must have been indefinitely greater than at present, and must have varied during the entire process of condensation. The question then naturally presents itself whether the ratio of a planet's diameter to that of its sphere of attraction may not have some connection with its present polar compression. Perhaps it may not be improper to remark that these ratios in the case of Mars and Uranus are about equal, and each very much greater than in any other planet.

I shall now consider the objection that my analogy assigns inadmissible elements to the hypothetical planet between Mars and Jupiter. And first in regard to the mass. Thirteen supposed fragments have been discovered in this region; nine having been detected within the last five years. The dimensions of all are admitted to be extremely uncertain. The apparent diameters of only four,—Vesta, Juno, Ceres, and Pallas,—have been taken; and in regard to these, the measurements of Herschel, Schrœter, and Mädler are very discordant. According to the determination of Schrœter the sum of their volumes is more than equal to one-fourth that of Mars. Adopting this estimate, therefore, and assuming that their average magnitude is equal to that of the remaining nine, the thirteen already discovered would be nearly equal to Mars. It may not be improper to remark in this connection that the apparent brilliancy of the asteroids does not always seem to increase with the magnitude. Pallas, which according to both Mädler and Schrœter, is very much larger than Vesta, appears as a star of the eighth magnitude, while the latter is of the sixth, and has been seen by the naked eye.

But the objection to the mass of the hypothetical planet, even adopting Mädler's values, does not appear to me very important. What is there improbable in the supposition that hundreds or even thousands of asteroids, too small to be detected by our telescopes, may revolve in this mysterious cluster? Indeed, if we may judge from the recent success which has attended the researches of astronomers, it would seem by no means unreasonable to suppose that a number much greater than has yet been observed, may be hereafter discovered.

The great discrepancies, however, in Prof. L.'s estimates result in part from his assuming a period of twenty seven hours as the time of rotation of "the asteroid planet." His authority for this assumption is the fact that Schrœter from some of his observations supposed *Juno* to complete a revolution in that time. If we admit the correctness of Schrœter's inference (which is doubtful), it can afford no evidence whatever, that the *original* planet revolved in the same or nearly the same period.

In regard to the values of the constant $\frac{n}{D^{\frac{3}{2}}}$, for Mars and Jupiter, it is sufficient to say that by using the received masses of these bodies, and certain values of the mass, distance and time of rotation of the intervening planet, involving no absurdity, they perfectly harmonize with the law of rotation. In the case of Saturn there is no discrepancy worthy of notice.

The objection drawn from the analogies observed in the planetary system may be stated as follows: The eight principle primary planets consist of two distinct classes; the members of each exhibiting "a strong family likeness." Uranus is included in the same class with Jupiter and Saturn; hence the probability that his period of rotation does not differ very much from theirs. The class of minor planets includes Mercury, Venus, the Earth and Mars. Of these the periods of rotation are nearly the same; varying between 23h. 20m. and 24h. 40m. Now "if we suppose the asteroids to have been once united in a single body, probably no one would hesitate to assign it" to the last of these classes.

The argument here urged against the truth of my law, is, that it makes the period of rotation of the original body between Mars and Jupiter, as well as that of Uranus, entirely different from those of all the planets whose rotary velocity has been ascertained. It is a remarkable fact, however, that *in other respects* extraordinary peculiarities in the primitive constitution of those two bodies unquestionably obtained. I refer to the unknown causes which produced the avulsion of the ancient planet, and the anomalous motions of the satellites of Uranus.

Prof. L.'s discrepancy in the values of $\frac{n}{D^{\frac{3}{2}}}$ for Venus and the Earth results in part from his employing Encke's mass of Mercury, confessedly only an approximation. The mass adopted by Prof. Walker is the mean of this value and the first and second masses of Leverrier.

With regard, then, to the *unknown* mass and period of the hypothetical planet, and the rotation of Uranus, discussion would be next to useless. That my formula harmonizes with the *known* elements of the solar system as exactly as even recent determinations of the masses of the planets by different astronomers agree

with each other, is simply a fact which admits of no controversy. We have then at least seventeen* independent variable quantities which harmonize together in a complicated formula. In regard to each of these there are many chances to one against its value being such as to produce the existing harmony; hence the probability is almost infinity to unity against the accidental coincidence of the whole. The conclusion seems irresistible that my formula is the expression of a law of nature.

Pottsville, Pa., March, 1851.

ART. XLV.—*New Genera of Fossil Corals from the Report by* JAMES HALL, *on the Palæontology of New York.*

THE researches of Mr. James Hall into the palæontology of New York have been carried forward with great labor and careful investigation, and are an honor to the state under whose liberal patronage and direction they are continued. The region included within the limits of the state, embraces the whole range of the Silurian and Devonian rocks, and in no part of the world is this series of strata more fully developed, or more abundant in organic remains. The completeness of the system here displayed will make it classic ground for the student of the ancient life on our globe, and Mr. Hall's work, in which these relics of antiquity are described, must become of standard importance the world over. The first volume, a thick quarto, with nearly a hundred plates, was published in 1847. A second volume of equal extent has been for some time ready to be issued excepting a few plates yet unfinished. This is hardly half the work before him—although 722 species have been thus far described; for the fossils are strewed through many of the rocks of the state with the most wonderful profusion, and the whole number of species they include cannot be less than 1800. We propose in this place to cite the descriptions of some of Mr. Hall's new genera from the second volume. We confine ourselves at present to the fossil corals. The strata whose fossils are described in this volume, are those of the Medina sandstone, and the following beds to the Onondaga Salt Group; over 200 pages of the volume are devoted to the Niagara Group.—EDS.

New Genera of Fossil Corals.—1. *Clinton Group.*

Genus HELOPORA, *Hall*, p. 44.—[Bryozoöid?] Simple or branching cylindrical stems, often swelling at the upper extrem-

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* Viz.: The distances and masses of Mercury, Venus, the Earth, Mars, Jupiter, Saturn and Uranus, and the periods of rotation of Venus, the Earth and Saturn.

ity, poriferous on all sides. Pores oval or subangular, arranged between longitudinal elevated lines.—Species *H. fragilis.*

Genus PHÆNOPORA, *Hall*, p. 46.—[Bryozoöid.] Corallum consisting of a thin broad calcareous or semicalcareous expansion which is celluliferous on both sides; cellules oval, arranged between direct longitudinal and obliquely transverse lamellæ, and opening upward and outwards from the base. Near Fenestella in general aspect.—Sp., *P. explanata*, *P. constellata*, *P. ensiformis.*

Genus RHINOPORA, *Hall*, p. 48.—[Bryozöoid?] Corallum consisting of an expanded calcareous crust, either subcylindrical and hollow or explanate, poriferous on the two sides; cells arranged somewhat in quincunx order, roundish or oval, and strongly raised in little papillæ or pustules above the surface.—Species *R. verrucosa*, *R. tubulosa.*

2. *Niagara Group.*

Genus POLYDILASMA, *Hall*, p. 112.—Corallum turbinate [Cyathophylloid]; lamellæ numerous, thin, apparently rising in pairs and one often much stronger than the other; cell broad, margin thick and strong, with a deep central pit; half the lamellæ reaching to the centre of the cell, where they are complicated or contorted; transverse septa below the central part of the cup obsolete or irregular. Allied to Calophyllum, but does not show the transverse septa characteristic of that genus.—Sp., *P. turbinatum.*

Genus CONOPHYLLUM, *Hall*, p. 114.—Corallum turbinate or subcylindrical, having transverse septa in the form of inverted cones set one within the other; rays or lamellæ very thin, numerous and denticulate. In weathered specimens the transverse septa often project beyond the sides the coral above, and the whole appears somewhat like a series of inverted cones. The weathered surfaces have sometimes the appearance of Cystiphyllum, from the irregular meeting of the upper and under surfaces of the successive transverse septa.—Sp., *C. Niagarense.*

Genus DIPLOPHYLLUM, *Hall*, p. 115.—Simple; ramose or aggregated cylindrical stems; corallum composed of two distinct portions, the inner transversely septate, the outer with fine transverse dissepiments uniting the lamellæ which are continuous to the centre; cell deeply concave in the centre and separated from the outer portion by a distinct rim, both the inner and outer portions stellate, with the same number of rays. Near the Diphyphyllum of Lonsdale.—Sp., *D. cæspitosum.*

Genus ASTROCERIUM, *Hall*, p. 120.—Coral massive (or ramose?); interior prismatic or basaltiform; cells contiguous, openings upon the surface more or less angular, and often very variable in size; rays twelve or more, consisting of slender elongated and ascending points; transverse septa direct. Near *Favosites*, and more especially, *Favistella*, but with spiniform rays instead

of lamellar.—Sp., *A. venustum*, *A. parasiticum*, *A. pyriforme*, *A. constrictum.*

Genus Cladopora, *Hall*, p. 137.—Ramose or reticulate, branches cylindrical or slightly compressed, terminations terete; coral composed of a series of tubes or cells radiating equally on all sides from the axis, and opening upon the surface in rounded or subangular expanded mouths; cells more or less closely arranged, but not always contiguous and apparently destitute of septa or rays. The cells when filled with calcareous matter frequently separate in prismatic forms like Favosites, but there is no evidence of transverse septa. The cells are not always contiguous, and there is often a space between the cells which appears to be solid in one or more species.—Sp., *C. seriata*, *C. cespitosa*, *C. cervicornis*, *C. fibrosa*, *C. multipora*, *C. macrophora*, *C. reticulata.*

Genus Calopora, *Hall*, p. 144.—Ramose or incrusting with a columnar structure; cells tubular with the apertures circular or petaloid, not contiguous, and having the intermediate spaces occupied by angular cell-like openings which are transversely septate; tubular cells rarely septate.—Sp., *C. elegantula*, *C. florida*, *C. laminata*, *C. aspera*, *C. nummiformis.* The *Hetiopora crassa* of Lonsdale is probably of this genus.

Genus Trematopora, *Hall*, p. 149.—Ramose or incrusting, composed of tubular cells more or less closely arranged; intermediate spaces solid on the surface, but in the interior transversely septate; cells not septate; apertures oval or circular, often contiguous, margined by a thin elevated border or calicle, which on the lower side is often prominent or labellate. Near *Calopora*, but calicle or elevated rim more conspicuous, and intervals between cells solid instead of cellular.—Sp., *T. tuberculosa*, *T. coalescens*, *T. tubulosa*, *T. punctata*, *T. ostiolata*, *T. solida*, *T. striata*, *T. granulifera*, *T. aspera*, *T. spinulosa*, *T. sparsa.*

Genus Striatopora, *Hall*, p. 156.—Ramose; corallum solid; stems composed of angular cells; apertures of the cells opening upon the surface into expanded angular cup-like depressions; interior of the cell rayed or striated, striæ extending beyond the aperture of the cell.—Sp., *S. flexuosa.*

Genus Clathropora, *Hall*, p. 159.—Bryozoöid. Ramose or reticulate; uniformly poriferous on both sides of the reticulate fronds, and on all sides of the stems and branches of ramose forms; apertures of cells more or less quadrangular, regularly arranged in series parallel to the direction of stems, or obliquely in quincunx order. Near Retepora in habit.—Sp., *C. alcicornis*, *C. frondosa.*

Genus Ceramopora, *Hall*, p. 168.—Bryozoöid. Incrusting or in flattened hemispherical forms; cells arranged in alternating or imbricate series; apertures arching or triangular, with the apex

above.—Sp., *C. imbricata*, *C. incrustans*, *C. foliacea*. The *Berenicea irregularis* of Lonsdale, and *B. megastoma* of M'Coy, are here related.

Genus LICHENALIA, *Hall*, p. 171.—Bryozoöid. Membranous or subcalcareous, growing in circular or flabellate forms, concentrically or radiately striate, celluliferous on one surface only; frond usually a thin membrane, though often unequally thickened and contorted or wrinkled. It is only in rare instances that distinct cells are visible, though in most cases the surface appears marked as if by stigmata or the commencement of cells, which sometimes rise in low nodes without presenting any defined apertures.—Sp., *L. concentrica*.

Genus SAGENELLA, *Hall*, p. 172.—Bryozoöid. Thin membranous, net or web-like, incrusting; cells arranged in regular parallel or diverging series more or less oblong quadrangular when in juxtaposition, and separated from each other by a thin lamina of calcareous matter.—Sp., *S. membranacea*.

Genus DICTYONEMA, *Hall*, p. 174.—Bryozoöid, and near Fenestella. Frond circular or flabelliform, composed of slender radiating branches which frequently bifurcate as they extend towards the margin; branches and subdivisions united laterally by fine transverse branchlets; branches impressed with deep striæ or grooves, producing indentations that sometimes have an elongated rhomboidal form; axis subcalcareous with a corneous exterior. Branches sometimes like a graptolite in appearance.—Sp., *D. retiformis*, *D. gracilis*.

Genus INOCAULIS, *Hall*, p. 176.—A plant-like corneous coral with numerous bifurcating branches; structure fibrous or plumose. The texture is like that of Graptolites, a black scaly crust or film being all that remains of the substance. Probably grew in groups of rounded or flattened stems dichotomous above. —Sp., *I. plumulosa*.

ART. XLVI.—*Analyses of Pitchstone Porphyry from Isle Royale, and of a Crystal of Phosphate of Lime from Hurdstown, New Jersey;* by C. T. JACKSON, M.D., Assayer to the State of Massachusetts. (Read before the Boston Society of Natural History, March 19, and communicated to this Journal by the author.)

1. *Pitchstone Porphyry from Isle Royale, Lake Superior.*

Description.—It occurs in rounded pebbles, on the shores of Isle Royale, near Scovill's Point. Color of the pitchstone, jet black, lustre more vitreous than obsidian. Fracture conchoidal. Sp. gr. = 2·375. Hardness 5½. B. B. swells very much, exfoli-

ating and becoming ash grey; at a higher temperature melts into an apple-green blebby glass. The pebbles are porphyritic with crystals of glassy feldspar, and contain occasional amygdules of carbonate of lime, surrounded with a jaspery red crust, and a thin layer of chlorite.

Chemical analysis of the Pitchstone.—The black mineral, carefully picked, was reduced to fine powder by levigation—dried at 212° F., and analyzed in two separate parcels of one gramme each; one for the silica, alumina, lime, manganese, oxyd of iron, and water, and the other for the alkali, with the following results, per cent.

Silica,	67·90
Alumina,	11·20
Peroxyd of iron,	6·40
Lime,	3·10
Oxyd of manganese,	0·80
Soda,	2·61
Water,	8·00
	100·01

These results were verified by repetition on separate portions of the mineral, the water having been distilled in a glass tube and proved to be pure, no organic matter of any kind existing in the mineral, and no alkali but soda.

It is evident that this mineral is analogous to the pitchstone porphyry of the island of Arran, in Scotland; and since it has not, so far as I know, been before discovered in the United States, these results may prove interesting to mineralogists. It is not known, whether it occurs *in place* in the trap rocks, or in the conglomerate which contains the debris of porphyry rocks.

Should I be again called to reëxamine the geology of Lake Superior mineral lands, I shall endeavor to settle this, with other questions, interesting to men of science.

2. *Crystal of Phosphorite from Hurdstown, N. J.*

This crystal had a yellow color, and was remarkably resplendent on the surface like those from St. Lawrence county, New York, appearing as if fire-glazed. Its sp. gr. is = 3·205.

Chemical analysis.—By qualitative analysis, it was first proved to contain fluorine and chlorine, phosphoric acid, lime, oxyd of iron, and manganese.

The fluorine is sufficiently abundant in it to cause deep etching on glass, when it is disengaged by the action of sulphuric acid. Specimens of this etching I exhibited at the meetings of the American Academy of Arts and Sciences last August.

By quantitative analysis, the mineral was found to consist of

Phosphate of lime, ...	92·405
Chlorid of calcium, ...	·540
Peroxyd of iron, ...	·040
Oxyd of manganese, ...	·003
Fluorid of calcium, by difference,	7·012
	100·000

If the oxyd of iron is regarded as protoxyd, it will amount to 0·036 instead of 0·040, but the color forbids its being set down as the protoxyd. The mineral is evidently identical with apatite.

Boston, March 27, 1851.

ART. XLVII.—*On the Volatility of Phosphoric Acid in Acid Solutions when heated; and on Schmidt's Process for the Determination of Nitrogen;* by J. B. BUNCE, of the Yale Analytical Laboratory. Communicated by Prof. J. P. Norton.

1. *On the Volatility of Phosphoric Acid in Acid Solutions.*

ROSE, in a paper upon the determination of phosphoric acid, mentions the volatility of this acid with the vapor of water, when evaporated in an acid solution. The object of the following experiments, was to ascertain the extent of loss which would be suffered in analysis in consequence of this volatility. With this object in view, ·544 grammes of phosphate of soda were dissolved in a gill of water; hydrochloric acid was then added, and the whole evaporated in a water-bath to dryness, being afterwards heated gently to drive off any excess of acid. The residue was treated with strong sulphuric acid, and allowed to stand several hours in order to convert the pyrophosphate of soda into the ordinary tribasic salt. It was then diluted carefully, neutralized by ammonia, and precipitated as ammonio-phosphate of magnesia; the weight of this salt after ignition, was ·0701 grammes, equal to ·045 of phosphoric acid. The consequent loss of phosphoric acid in this experiment was 58·66 per cent. Another experiment in which the chlorine instead of the phosphoric acid was determined, gives as the loss of acid 53·36 per cent.

·2 grammes of phosphate of magnesia and ammonia were next taken, dissolved in hydrochloric acid, diluted until about a gill of fluid was obtained, and the whole was then evaporated as before; after precipitation and ignition, the residue weighed ·1316, corresponding to 41·69 per cent. of phosphoric acid. The per-centage of phosphoric acid in the ammonio-phosphate of magnesia, as determined by ignition, was 48·37 per cent. Consequent loss of phosphoric acid 6·67 per cent.

Another experiment conducted in the same manner, with the exception that the pyrophosphate of magnesia was converted into the tribasic condition, by fusion with carbonate of soda, gave 8·35 per cent. as the loss. The loss of phosphoric acid when the solution was acidified with sulphuric acid instead of hydrochloric acid was greater, probably owing to the higher degree of heat required to volatilize that acid. There was no perceptible difference between the action of hydrochloric and nitric acids. Phosphate of soda was completely converted into the sulphate of the same, by three evaporations with sulphuric acid and water. Phosphates of alumina, iron, lime and magnesia were not perfectly converted into sulphates even by a dozen successive evaporations. Phosphoric acid does not seem to be more volatile in the vapor of alcohol than in that of water.

These experiments serve to show that the ordinary methods of analysis are not applicable to the analysis of phosphates which must be dissolved in acid by the aid of heat. In the ordinary evaporations to separate silica by rendering it insoluble, a very considerable loss of this acid is occasioned. The estimated quantity of phosphoric acid in ashes, &c., must probably in many cases be much too low, owing to this loss from volatilization, and we may believe that for this reason many analyses must be regarded as almost valueless with respect to the amount of phosphoric acid which they indicate.

2. *On Schmidt's Process for the Determination of Nitrogen.*

Chemists engaged in organic analysis have long felt the want of a quick and accurate process, for the determination of nitrogen. Several objections may be offered to the method of Messrs. Will and Varrentrapp—in following which, the substance to be analyzed is burned in contact with soda-lime, the ammonia formed is passed into a solution of hydrochloric acid gas, and after evaporation precipitated as ammonio-chlorid of platinum. The more important of these arises from the solubility of the platinum salt, and the time required for the evaporation, drying, weighing, &c. In Liebig's report for 1847 and '48, mention is made of several new methods for the determination of nitrogen. Of these that of Schmidt attracted my attention and I was led to make some experiments upon it. He burns the substance as in the Will and Varrentrapp process, and passes the ammonia formed into a solution of one part chlorid of barium in eight parts of water: through this a constant stream of carbonic acid is passed, and from the precipitated carbonate of baryta, the nitrogen in the analyzed substance is calculated by equivalents. In experimenting on this process, I burned carefully crystallized ferrocyanid of potassium, which had been proved pure by previous experiment: and I obtained results

differing so widely from each other that I was led to suspect some serious difficulty in the process. It was found upon trial, that carbonate of baryta was partially decomposed by boiling with chlorid of ammonium in a neutral solution, and also that chlorid of ammonium when boiled by itself is converted into an acid salt. This holds true with many of the salts of ammonia with the stronger acids. A solution of chlorid of calcium in alcohol produced no better results. The precipitated carbonate of lime was decomposed by the chlorid of ammonium formed, even in presence of alcohol.

I then tried some of the organic salts. Succinic acid gives with chlorid of barium no precipitate, but upon the addition of ammonia a fine crystalline precipitate is produced, only slightly soluble in water, and insoluble in alcohol. But as succinate of baryta is slightly soluble in ammoniacal salts, it was found that no use could be made of this method.

It would appear therefore that none of these modifications are capable of affording accurate results, and that the original process by Schmidt, unless some very essential feature is omitted in our account of it, must be considered faulty.

ART. XLVIII.—*On Bromine as a Toxicological agent;* by HENRY WURTZ, Assistant in the Yale Analytical Laboratory.

I HAVE not found in the various toxicological writings any suggestion as to the use of bromine for destroying the organic matter of stomachs. Nevertheless, the unparalleled intensity of its action upon organic tissues, together with the convenience of its use, seem to give it some advantage over the ordinary agents used for this purpose.

An experiment to this effect was made upon a human stomach sent to this laboratory for examination.

The entire stomach with its contents, in the same state in which it was sent, was introduced into a porcelain dish, covered with water, and about an ounce of bromine poured in, which had been previously ascertained to be free from any other substance of a poisonous nature.

A gentle heat was now applied, much below the boiling point of water, and the stomach was turned over from time to time with a glass rod.

(Especial care should be taken that this operation be performed in a strong draught, because the action of the bromine vapors upon the lungs and eyes is injurious beyond the ordinary belief. In case of accidental injury from this cause, the best antidote is inhalation of chloroform or ether.)

When the stomach had completely disappeared, which took place in less than half an hour, some hydrochloric acid was added and the heat continued for a few minutes longer. The liquid was now ready for filtration and left upon the filter only a few flakes of organic matter, together with a little fat and that portion of the contents of the stomach which was insoluble in hydrochloric acid. It may be here noticed that a piece of paper which had been improperly wrapped around the stomach by those who sent it, and which could not be separated from it, also a cotton string which had been tied around it by the same parties, were also completely destroyed by the bromine.

In the filtrate, arsenic, antimony, mercury, etc., were searched for by the usual methods.

To preclude all fear of fallacy in this process, I may add that an experiment was made to ascertain whether the volatility of the bromids of arsenic, antimony, and mercury could influence the result.

A liquid which contained just detectable traces of arsenious acid, tartar emetic and corrosive sublimate, was evaporated to dryness in the presence of a large excess of bromine. In the residue were still easily detected arsenic, antimony and mercury. This result does not, of course, touch the question whether arsenic and antimonic acids are volatilized like phosphoric acid, by evaporation of their acid solutions, either without decomposition or as terbromids or quinquibromids of arsenic and antimony, the decision of which would require many special experiments.

In fact, the experiments of Dupasquier, which have an indirect bearing upon this question, show that *arsenious acid* when evaporated in the presence of a large quantity of hydrochloric acid, may be entirely volatilized, probably as terchlorid of arsenic.* Dr. Wolcott Gibbs recently informed me that he has had occasion to confirm this observation of Dupasquier.

The boiling points, however, of the terbromids of arsenic and antimony are quoted at 428° and 518° F., respectively, while the chlorids of the same metals boil at 270° and 446° F., which facts evidently render the chance of loss in the bromine process less than in the old processes.

Art. XLIX.—*On an Improved Remontoire Escapement for an Astronomical Clock;* by J. Fulton.

If a simple pendulum, vibrating seconds in a very small arc, is made to describe any of the arcs in the following table, the daily loss will be according to the extent of the arc made on each side of the point of rest, as shown there.

* Gmelin's Handbuch, ii, 709.

Arcs described on each side	Inches and decimal parts.	Daily loss.
0° 15′	0·165	0·1 sec.
0 30	0·337	0·4
1 0	0·674	1·6
2 0	1·349	6·6
3 0	2·024	14·8
4 0	2·699	26·3
5 0	3·374	41·1

By inspecting the above table, taken from Reid's work, on Clock and Watch making, page 153, it may readily be inferred that any cause producing a change in the extent of the arc of vibration, will cause a change in time. Now, as practical difficulties prevent the use of a cycloid arc, in which long and short vibrations would be equal in time it becomes a matter of importance to adopt such measures as will cause the pendulum to keep one regular arc of vibration, without increase or diminution.

For this purpose, remontoire escapements have been tried, in which the weight, through the train of wheels, is made to lift a small weight, or bind a spring, and this again to communicate impulse to the pendulum. But I believe they have not been found effectual on account of the great amount and consequent inequality of friction, in the unlocking of the teeth of the scape wheel, which has to be performed by the pendulum.

It occurred to me some years since that it would be possible so to reduce the friction in the unlocking of a remontoire escapement, as to leave the pendulum almost entirely to its free natural motion, which being kept up by equal impulses, would be always in equal arcs. With this end in view I contrived an escapement, which I have brought through various stages of improvement; and now respectfully offer to the public as here set forth.

(The plates, weight, train of wheels, &c., up to the scape wheel may be as in other clocks.)

1.

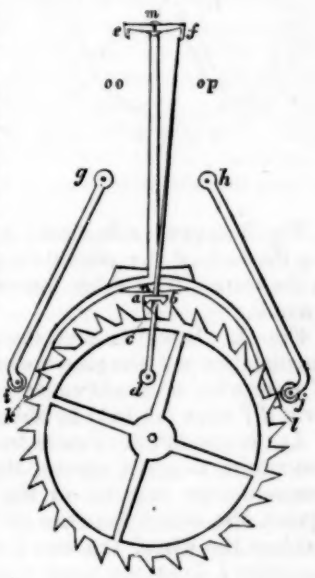


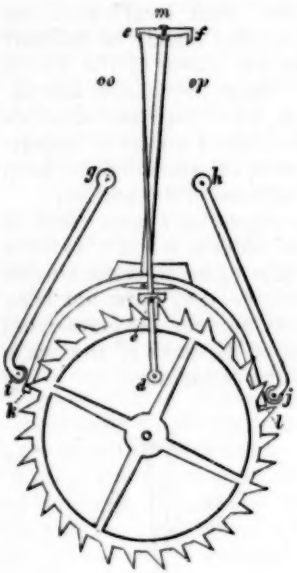
Fig. 1.—*k a b l*, the scape wheel. *a b*, pair small pallets with pivots at *c*, and lever *d f* on the same arbor, but broken away about the arbor to show the pallets.

g i and *h j*, two remontoire weights, with pivots at *g* and *h*, and rollers at *i* and *j*.

m n, the pendulum guide, with two arms *n k* and *n l*, extending down to reach the rollers of the remontoire weights.

e f, pair locking pallets attached to the arbor of the pendulum guide, to lock the lever *d f*. (The axis *m* of the pendulum guide coincides with that about which the pendulum vibrates.)

2.



3.

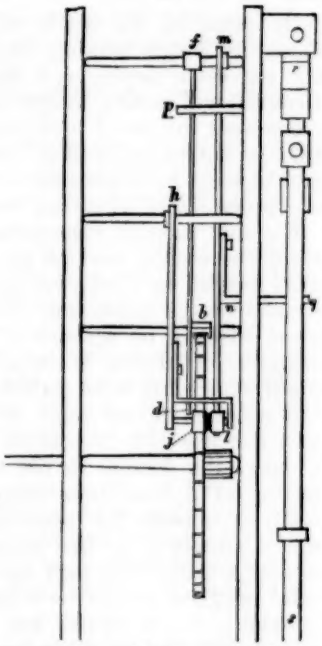


Fig. 3 shows a side view; *r s* part of the gridiron pendulum; *n q* the fork of the pendulum guide passing through an aperture in the plate. The other letters show the same parts as in figs. 1 and 2.

Fig. 1. It will be seen that, as the wheel is urged forward in the direction *a b*, the pressure of a tooth against the inclined plane of the pallet *a*, would cause it to move out of the way, if the lever *d f* were not held by the pallet *f*.

As the pendulum vibrates from left to right, the pressure of the remontoire weight *i*, against the arm *k* of the pendulum guide, communicates impulse to the pendulum till the roller lodges against the wheel, between two teeth; but just before the roller touches the wheel, the arm *l* will come in contact with and lift the roller *j*, from the point of the tooth on which it rests: and

by the same motion the lever will be unlocked from the pallet *f* by the time the roller *j* is fairly out of the way of the wheel; at which time the pressure of the tooth against the inclined plane of the pallet *a*, will cause the lever to move toward and strike against the pin at *p;* when the tooth will escape from the pallet *a;* the wheel will move forward half the distance between two teeth, and raise the roller *i*, till it rests on the point of the tooth; a tooth will come in contact with the inclined plane of the pallet *b*, and cause the lever to move toward and lodge against the pallet *e*, as seen in fig. 2, where it will remain till the pendulum completes its vibration; and when it returns from right to left, the remontoire weight *j* will give impulse to the pendulum, till it lodges against the wheel behind the tooth on which it formerly rested, as seen, fig. 2; the arm *k* will raise the roller *i*, from the point of the tooth on which it will find it; immediately the lever will be freed from the pallet *e;* the pressure of a tooth against the pallet *b*, will cause the lever to strike the pin at *o;* the tooth will escape from the pallet *b*, and the wheel will move forward half the distance between two teeth, raising the roller *j* to the point of the tooth; a tooth will come against the pallet *a*, fig. 1, and cause the lever to lock against the pallet *f:* the pendulum, after completing its vibration, will again proceed to the right, and the same movements will be repeated.

If in fig. 1, the distance from the pallet *a* to the fulcrum *c*, is one-twelfth of an inch, and the length of the lever from *c* to *f* is three inches; the pressure of the lever against the pallet *f* will be only about one thirty-sixth of the pressure against the pallet *a*. Now, if in connection with this we remember that the distance *m f*, is much shorter than the distance from *m* to *i*, the point where the unlocking would be, if made from the scape wheel, we may readily conclude that the resistance to the pendulum in this unlocking is almost nothing compared with that in other escapements.

In the above specification I have endeavored to avoid all unnecessary minuteness; but perhaps it will not be amiss farther to observe that the lever *d f* should be extremely light, and accurately balanced on its pivots. The pallets *a b*, should be half the distance between two teeth apart, and on opposite sides of their axis. The axes of the remontoire weights should be placed in straight lines passing from the axis of the pendulum guide and touching the points of the teeth of the scape wheel, and far enough apart to allow room for the lever *d f* to play between its bankings. The diameter of the rollers should be equal to about two-thirds of the distance between two teeth. If oil is to be used on the pallets *a b*, it would be well to turn a crease around the center of the roller as shown in fig. 3. When the wheel raises a remontoire weight, it should stop before the tooth comes

quite up to a line drawn from the center of the roller to the center of the wheel. The pendulum guide should be as light as possible, that there may not be much friction at its pivots. I think everything farther necessary, and perhaps much that has been said, would readily suggest itself to any skillful workman that might undertake to execute an escapement on this principle.

I have a more simple form of this escapement, which gives impulse to every second beat of the pendulum in operation in a time-piece, with half seconds pendulum which performs extremely well. But I suppose the form giving impulse both ways would be preferred for an astronomical clock, as the second hand will mark seconds, and the beats will be equal and will sound alike.

This escapement is susceptible of being used to compensate for the expansion and contraction of the pendulum rod by change of temperature. If the remontoire weight, instead of stopping against the wheel, were made to stop against an apparatus of brass and steel soldered together, which in warm weather would not allow it to descend as far as in cold, the pendulum would take a shorter arc in warm, than in cold weather, which would tend to neutralize the effect of its expansion. How accurate it might be made I am not prepared to say: it would require the pendulum to vibrate in pretty wide arcs. Perhaps the principle might be used with advantage in turret clocks in connection with the form of escapement giving impulse in only one direction, which has but one remontoire weight.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Experimental Researches in Electricity;* By Michael Faraday, Esq., D.C.L., F.R.S., &c.—(Proc. Roy. Soc., Phil. Mag., 4th Ser. i. 68.)—(1.) Twenty-fourth Series.—*On the possible relation of Gravity to Electricity.*—Under the full persuasion that all the forces of nature are mutually dependent, and often, if not always, convertible more or less into each other, the author endeavored to connect gravity and magnetic or electric action together by experimental results, and though the conclusions were, when cleared from all error, of a negative nature, he still thinks that the principal followed and the experiments themselves deserve to be recorded. Considering that some condition of the results produced by gravity ought to present itself, having a relation to the dual or antithetical character of the magnetic or electric forces, it seemed to the author that the approximation of two gravitating bodies towards each other, and their separation, were the only points which offered this kind of coincidence; and therefore, using the earth as one gravitating body, he employed a cylinder of metal, glass, resins, or other substances, as the other, and endeavored to ascertain when the latter was allowed to

fall, being surrounded by a helix of wire, whether any electric current was generated. Sometimes the cylinder was allowed to fall through the helix; at other times with the helix; and occasionally the helix was made the falling body. But when the various sources of error which sprung up were gradually removed, no traces of electric action remained which could be referred to the power of gravity.

In order to obtain a greater effect, an apparatus was employed (being nearly that used in the 23rd Series of these Researches) by which the effect of raising a body from the earth could be combined with that of a falling body by the fit use of commutators (if any action at all were produced). The apparatus was very good, and gave exceeding delicate results, as was shown by other consequences of its action; but in respect of gravity it produced no effect whatever. Notwithstanding his failure in obtaining any experimental relation between gravity and magnetic or electric force, the author still expresses his conviction that there is a relation, and his hopes that it may be hereafter practically demonstrated.

(2.) Twenty-fifth Series.—*On the Magnetic and Diamagnetic Condition of Bodies.* Received September 9, 1850.—As the author could find no polarity in diamagnetic bodies when under magnetic influence (a result described in the 23rd Series of these Researches), he endeavored to discover some other physical condition of them, and of magnetic bodies, by which he might obtain an insight into their respective natures, and establish the true place of the magnetic zero; and considering the power with which a magnetic body moves, or tends to move, from weaker to stronger places of action, and that of a diamagnetic body to pass from stronger to weaker places of action, he hoped to obtain some results of condensation with the first class, and of expansion with the second, when they were subjected to very strong magnetic action; the respective bodies being selected from the class of gaseous substances, in which change of volume can be easily produced and measured. In the first place, therefore, a ray of light was passed over the surface of powerful magnetic poles surrounded by different gases, and the place of its source carefully examined by telescopes, micrometers, and other means, to ascertain whether the layer of air in contact with the poles was affected in its refracting force; but though the experiment was made in oxygen, nitrogen, and other gases, not the slightest effect was visible.

Resigning this process, therefore, two air-tight chambers were made, in which the magnetic poles formed the chief part of the internal surface of the chamber. The one was formed by bringing the flat ends of the two poles to within $\frac{1}{60}$th of an inch of each other, with a frame all round to form the sides; and the other by cutting away the central parts of an iron cylinder so as to give it the form of an hour-glass, and then enclosing that part by an air-tight copper tube. Cocks were attached to these chambers for the introduction and removal of gases, and for the application of gauges which were able to indicate a change of volume equal to the $\frac{1}{1000000}$th part of the contents of the chamber. When any given gas was introdued into the chamber, and the latter then placed between the poles of the electro-magnet, any possible alteration of volume would be shown by the gauge as soon as the mag-

net was rendered active; but whatever gas was employed, or whatever power of magnet used, not the slightest change was produced.

Thinking it possible that there might be expansion in one direction and contraction in another, the gases were then examined as to the production of any currents in them, but no traces of such appeared.

From these results, the conclusion was arrived at by the author, that the motions of magnetic and diamagnetic bodies in each other do not appear to resemble those of attraction or repulsion of the ordinary kind, but to be of a differential action, dependent perhaps upon the manner in which the lines of magnetic force were affected in passing from one to the other during their course from pole to pole; the differential action being in ordinary cases between the body experimented with and the medium surrounding it and the poles. A method of showing this action with the gases is described, in which delicate soap-bubbles are made to contain a given gas, and these when held in the magnetic field, approach, or are driven further off, according as they contain substances, magnetic or diamagnetic, in relation to air. Oxygen passes inwards or tends toward the magnetic axis, confirming the results formerly described by the author in his account of his investigations of flame and gases.

Perceiving that if two like bubbles were set on opposite sides of a magnetic core or keeper cut into the shape of an hour-glass, they would compensate each other, both for their own diamagnetic matter and for the air which they would displace; and that only the contents of the bulbs would be virtually in a differential relation to each other, the author passed from bubbles of soapy water to others of glass; and then constructed a differential torsion balance to which these could be attached, of the following nature:—A horizontal lever was suspended by cocoon silk, and at right angles, at the end of one arm, was attached a horizontal cross-bar, at which, about 1½ inch apart, and equidistant from the horizontal lever, were suspended the glass bubbles; and then the whole being adjusted so that one bubble should be on one side of the iron core and the other on the other side, any difference in their tendency to set inwards or outwards from the axial line caused them to take up their places of rest at different distances from the magnetic axis; and the power necessary to bring them to an equidistant position became a measure of their relative magnetic or diamagnetic force.

In the first place, different gases were tried against each other, and when oxygen was one of them that went inwards, driving every other outwards. The other gases when compared together, gave nearly equal results, and require a more delicate and finished balance to measure and determine the amount of their respective forces.

The author now conceived that he had attained to the long-sought power of examining gaseous bodies in relation to the effects of heat and the effects of expansion separately; and proceeded to an investigation of the latter point. For this purpose he prepared glass bubbles containing a full atmosphere, or half an atmosphere, or any other proportion of a given gas; having thus the power of diluting it without the addition of any other body. The effect was most striking. When nitrogen and oxygen bubbles were put into the balance, each at one atmosphere, the oxygen drove the nitrogen out powerfully. When the

oxygen bubble was replaced by other bubbles containing less oxygen, the tendency inwards of the oxygen was less powerful ; and when what may be called an oxygen vacuum (being a bulb filled with oxygen, exhausted, and then hermetically sealed) was put up, it simply balanced the nitrogen bubble. Oxygen at half an atmosphere was less magnetic than that at one atmosphere, but more magnetic than other oxygen at one-third of an atmosphere ; and that at one-third surpassed the vacuum. In fact, the bubble with its contents was more magnetic in proportion to the oxygen it contained. On the other hand, nitrogen showed no difference of this kind ; whether a bubble contained that gas more or less condensed, its power was the same. Other gases (excepting olefiant and cyanogen) seemed in this first rough apparatus to be in the same condition. The air-pump vacuums of all the gases were alike, including that of oxygen.

Hence the author decides upon the place for zero, and concludes that simple space presents that case. When matter is added to space it carries its own property with it there, adding either magnetic or diamagnetic force to the space so occupied in proportion to the quantity of matter employed ; and now thinking that the point of zero is well determined, he concludes to use the word magnetic as a general term, and distinguishes the two classes of magnetic bodies into paramagnetic and diamagnetic substances.

There is no other gas like oxygen ; its paramagnetic character is very high. A solution of protosulphate of iron in distilled water was prepared, of which a certain bulk in a glass bubble was of the same paramagnetic force as an equal volume of oxygen ; the solution was then of such strength as to contain of crystallized protosulphate of iron seventeen times the weight of the oxygen which could counterbalance it. In another case, a glass bubble, containing one-third of a cubic inch of oxygen, was opposed to a corresponding bubble having within only an oxygen vacuum. As soon as the magnetic power was on, the oxygen passed inwards, and it required a force equal to one-tenth of a grain to hold it out at the equidistant position.

The author then refers generally to the air as a paramagnetic medium, because of the oxygen it contains, and in the next, or Twenty-sixth Series of Researches, he proposes to enter, after some preliminary inquiries, into the great subject of atmospheric magnetism.

(3.) Twenty-sixth Series.—*On Magnetic Conducting Power and Atmospheric Magnetism.* Received October 9, 1850.—The remarkable results respecting oxygen and nitrogen described in the last Series, and the absence of any change of volume under strong magnetic action, led the author to apply for a time the idea of conducting power to the magnetic phenomena there described, meaning by that phrase the capability which bodies possess of affecting the transmission of the magnetic force without any reference to the process by which that transmission is affected ; and assuming that two bodies are at the same time in the magnetic field, and that one displaces the other, he considers the result as a differential effect of their difference in conducting power.

If a free portion of space be considered with lines of equal magnetic force passing across it, they will be straight and parallel lines. If a sphere of paramagnetic matter be placed in such a space, they will

gather upon and in the sphere, being no longer parallel in their course nor of equal intensity in every part; or if a sphere of diamagnetic matter replace the former sphere, the lines of force will open out where the sphere is, being again no longer parallel in direction nor uniform in force. When the field of magnetic force is formed between the opposite flat ends of two large magnetic poles, then these are affected, and the globes also, and there are mutual actions; a paramagnetic body, if a little elongated, points axially and tends to go to the iron walls of the field, whilst a similar diamagnetic body points equatorially, and tends to go to the middle of the field. Paramagnetic bodies repel each other, and so also do diamagnetic bodies; but one of each class being taken, they attract one another.

The convergence of the lines of force upon the opposite sides of the paramagnetic sphere, and the corresponding divergence of them on the opposite sides of the diamagnetic sphere, the author expresses by the term *conduction polarity*. This polarity he carefully distinguishes from that which depends upon the reversion of the direction of the power; the latter he considers as a property of the particles of magnetic matter; the former as dependant rather upon the action of the mass; the latter is an absolute inversion of the direction of the power, the former only a divergence or deflection of it.

Applying the idea of conduction to magnecrystallic bodies, he concluded that the magnecrystallic axis would coincide with the direction of better conduction, and thence concluded, that, if a symmetric crystal of bismuth were carefully examined in different directions, it would be found to be less diamagnetic when its magnecrystallic axis was perpendicular to the axis of magnetic force of the field in which it was to be submitted to experiment, than when it was parallel to the magnetic axis. By means of the differential torsion balance described in the former paper, he was able to make the trial, and found the results were as anticipated. With calcareous spar and his present balance he was not able to establish any difference, but concludes that it will prove most diamagnetic when the optic axis of the crystal and the magnetic axis of the field are parallel.

Advancing to the consideration of atmospheric magnetism, the author first refers to the earth as a source of magnetic power from which emanate lines of magnetic force passing into space according to a particular but recognized distribution, and in obedience to the general laws which govern the distribution of power about a given irregular magnet. In pure space the magnetic power is considered as transmitted onwards with a certain degree of facility which is constant, but may be increased or diminished by the presence of paramagnetic or diamagnetic matter within that space. The atmosphere is a portion of such matter, and can affect the magnetic lines which pass from the earth into space, and affects them differently according to variations which continually occur in it under natural circumstances. Four-fifths nearly by volume of the air is nitrogen, which is a gas that neither under any difference of temperature or of expansion shows any alteration in its power of affecting the transference of the magnetic force; whether added to space therefore in one state or another, or when undergoing changes of a corrresponding kind by natural cause, it has no influence

on the magnetic force. The perfect identity in magnetic action of hot and cold nitrogen, the author proves by new and delicate experiments. Oxygen forms the remaining fifth of the atmosphere. Its great magnetic changes by expansion have been described in the Twenty-fifth Series. Those produced by difference of temperature were described in the Philosophical Magazine for 1847, but are now resumed with more care, and found to belong to it alone, and not to nitrogen or carbonic acid; as its temperature is raised its paramagnetic force diminishes, being resumed as the temperature falls again. These properties it carries into the atmosphere, so that the latter is in reality a magnetic medium ever varying, from the influence of natural circumstances, in its magnetic power. If a mass of the air be cooled it becomes more paramagnetic, if heated it becomes less paramagnetic (or diamagnetic,) as compared with the air in a mean or normal condition.

The effect of the approach and retreat of the sun in his daily course is to produce such variations of changes in the temperature and expansion of the atmosphere as to influence the lines of force emanating from the earth, both in their direction and intensity; and the manner in which this influence will be developed is by means of figures and descriptions stated by the author in relation to the annual and daily variation, and the irregular perturbations of the magnetic force, which he thinks are consequences of it. He then applies the result of the magnetic observations at Hobarton as a test of the probable truth of the hypothesis, and considers that it affords strong confirmation. The upper or north end of the needle there goes west until about twenty-one o'clock, whilst the dip increases; the dip still increasing until noon, the upper end returns rapidly eastward, as the sun passes by, until two o'clock, the dip then decreasing; after which the needle goes west again, following the sun. On examining the results at Toronto, corresponding effects were found to occur, when the upper or south end of the needle was considered, and therefore in accordance with the hypothesis. The examinations of the observations made at Greenwich, Washington, Lake Athabasca, Fort Simpson, and St. Petersburgh, are considered as adding further confirmation. By the aid of these observations the author restates his principles more minutely, endeavoring to indicate what difference, changes in the inclination, declination, place of the sun, land, and sea, &c., will produce.

Though the sun is the cause of those changes in the atmosphere which affect the lines of force of the earth, he is not assumed as the centre of action as regards those lines; that is considered to exist somewhere in the atmosphere. It appears to be in the upper regions and not on the surface of the earth, because it increases the dip of places north and south of the tropics which have a certain amount of inclination, as at Hobarton, and Toronto, both in summer and winter, but it diminishes the dip at places which are within the tropics, and with little inclination, as St. Helena. By other kinds of observations, it appears to be in advance of the sun. All the phenomena indicate that the sun does not act directly on the needles at different places, but mediately through its effect on the atmosphere.

The author then considers the possible cause of numerous irregular variations, such as those that are shown by the photographic processes

of record at Greenwich and Toronto. The varying pressure of the atmosphere, the occurrence of winds and large currents of air, of rain and snow, of the passage of those masses of warm and cold air which the meteorologist recognizes in the atmosphere, of the aurora borealis, he considers may all produce changes in the lines of magnetic force, and become more or less sensible in the records of irregular variations. The author thinks it very possible that masses of air at different temperatures may be moved by the magnetic force of the earth, according to the principles of differential action made manifest in the experiments on warm and cold oxygen, in which case material as well as potential magnetic storms may exist. He concludes his paper by calling attention to the wonderful constitution of oxygen in its magnetical and electrical, as well as its chemical relations, to the offices it has to perform as part of the atmosphere.

(4.) Twenty-seventh Series. *Atmospheric Magnetism continued.* Received November 19, 1850.—In order to obtain an experimental representative of the action of the atmosphere when heated above or cooled below the average temperature, the author employed a ring helix of covered copper wire, through which an electric current was passed. The helix was about one inch and a half in diameter, and having the well-known system of magnetic forces, was placed with its magnetic axis parallel to a free needle; when its position was such that a needle within the ring would point with the north end downward, then the effect in deflecting the surrounding lines of force of the earth was considered as like that of a relatively paramagnetic mass of air; and when its position was reversed, its action was representative of that of a heated or relatively diamagnetic mass of air. Bringing this helix into the vicinity of small magnetic needles, suspended either freely, or so as to show declination or inclination, the planes of action or indifference as regards the power of deflecting the lines of force and the needle were observed. When the needle can move only in one plane, there are four quadrants, formed (in the case of the declination needle) by the intersection of the planes of the magnetic equator and meridian. When in these planes there is no deflection at the needle, but when in the quadrants there is, and in opposite directions in the neighboring quadrants.

As the lines of force are held in and by the earth, so these experiments were repeated with a needle in near vicinity to a magnet, and the difference of effect is pointed out; then the extent to which these results are applicable to those of the earth is considered, and their utility in guiding the inquirer.

The effect of heated air having been considered in the last paper, that of cold air is now taken up; and after considering its action in causing a contraction or drawing together of the terrestial lines of magnetic force, according to the principles of conduction before enunciated, the author considers generally where the regions of cold which travel round the earth every twenty-four hours will be in the northern and southern hemispheres, and how they will grow up and diminish in extent and importance as the sun moves north and south during the year. After which he applies these considerations, and the result of the experiments with the ring helix, to the explication of the changes of the needle as

they are given by observations at St. Petersburgh, Greenwich, Hobarton, Toronto, Cape of Good Hope, St. Helena and Singapore. In doing this, he endeavors to explain the night action, the early morning effect, the contrary course of the needle for the same hours in different months, the difference of local time dependent on the distribution of land and water, the cumulative effect of preceding months, and the continual effect, especially in the tropical regions, of the higher temperature of the northern hemisphere above that of the south. In all these points the author sees such an agreement between the natural results and those which are suggested by the assumed physical cause of the magnetic variations, as to give him a growing confidence in the truth of the views he has put forth.

2. *Daguerrotypes by Galvanic Light;* by B. Silliman, Jr.—In 1840, in company with Dr. W. H. Goode, I showed the possibility of taking impressions on an iodized silver plate by the light of a powerful voltaic pile. An account of our trials on that occasion was published in this Journal, first series, vol. xliii, p. 185.

Since that time my attention has not been called to the subject, until lately, when the arrival at the Louisville Laboratory of one of Duboscq's regulators of the galvanic light by an electro-magnet, suggested the propriety of repeating the experiment. The battery employed in 1840 was the extensive series of 900 pairs of zinc and copper all plunged at one movement, and which instrument is still (as then) in the laboratory of Yale College. The light from this arrangement was very intense, the arc of flame about four inches at the first instant but of course inconstant as well from the nature of the pile as from the absence at that time of any contrivance like that of Duboscq for its regulation.

The battery employed in the present trials was composed of fifty pairs of Bunsen's carbon battery made by Deleuil of Paris. Although very powerful, it could not be at all compared with the 900 members of the old arrangement in its initial effect, but this defect is more than compensated in its constancy. Our first trial was to make a copy of Thorwaldsen's Venus in plaster, placed at a distance of about twenty feet from the focus which was made in a large parabolic mirror with a silver surface. The camera was placed at about the same distance from the figure in such a position as to secure a favorable image. The plate was prepared with the usual sensitive coating of bromid of iodine, and the experiment was continued through about two minutes. The result showed that the relative distances of the light, the figure, and the instrument were not properly adjusted. An impression was produced but it was faint and required a longer exposure than usual to the vapor of mercury to develop it.

It was afterwards found better to bring the figure within about twelve feet of the light and also to approach the camera somewhat nearer. With this modification excellent impressions were procured in forty seconds—and it was the conviction of Mr. Stancliffe, the excellent daguerreotypist in Louisville, and who kindly aided me in these experiments, that even half that time would answer, as nearly all our plates were a little 'solarized,' if that term may be used in reference to galvanic light.

Our trials were not confined to inanimate objects, but good portraits of my friends and assistants, Mr. Brush and M. Dangiville, were also secured, in about one minute each. In the use of this light, care is required to avoid the deep shadows which are not relieved as in sunlight by natural reflection, and unless attention is paid to this circumstance, the impression appears disfigured by shadows of almost inky darkness.

Practically these trials may be considered of minor importance especially in the United States, where a fine sun-light may be obtained almost any day. But in the dark and murky atmosphere of London, it may become an important auxiliary in the art. Considering the easy manipulation of a good carbon pile, its constancy and the facile management of the light with the ingenious but simple apparatus of Duboscq, it certainly offers a tempting field of investigation as well to the practical daguerreotypist as to the student in optics. It is much more intense and equally manageable with the lime light, and consequently may be substituted for it in all optical demonstrations. Whether the properties of galvanic light are in all respects similar to solar light remains also an interesting question for future investigation.

Laboratory of Louisville University, February, 1851.

3. *Attraction of Electro-magnets.*—Dub has published the results of an elaborate investigation of the attractive forces exerted by electro-magnets upon armatures of different dimensions and placed at different distances from the magnet. The method of measurement employed was similar to that made use of by the author in a previous investigation, and consisted in observing in each case the weight necessary to tear the armature from the magnet itself, when the two were in actual contact, or to hold the attracting force in statical equilibrium when this was not the case. The magnets employed were straight cylindrical bars; the armatures similar bars of various dimensions attached successively to the arms of a balance, and held in exact equilibrium by weights placed in the opposite scale pan; the apparatus was so arranged that the perpendicular distance between the opposing faces of the magnet and the armature could be varied at will and accurately measured. The galvanic circuit employed consisted of a Grove's battery, a tangent's-compass, a rheostat, and the helix of the electro-magnet itself. The author sums up the results which he has obtained in the following terms.

(1.) The attraction diminishes very rapidly with the distance from the magnet.

(2.) The diminution of the attraction is greater in proportion as the attraction itself is small when the attracting surfaces are in contact, the surface of contact remaining the same.

To give a definite idea of the absolute amount of this diminution, the author states that in no one of his experiments was there an attracting force which at a distance of $\frac{1}{1000}$ of an inch was greater than half or less than one-fourth of the attraction during contact.

(3.) After a certain distance, the attraction is less in proportion as the magnet or the armature or both are thinner. (Although in general the attraction is not directly proportional to the diameter of the magnet or armature.)

(4.) Pointed armatures and magnets exhibit at a distance less attraction than cylinders of the same diameter.

(5.) The attraction of armatures and magnets of equal diameter increases (in contact or at a distance) with their lengths.

(6.) With magnets and armatures of equal weight, the attraction diminishes more slowly in proportion as these are shorter and thicker.

(7.) After a certain distance armatures of equal mass are equally attracted.

(8.) Magnets of equal weight have an equal attractive force at a distance, when, with the same galvanic effect, the spiral surrounds the magnet throughout its whole length.

(9.) With an equal surface of contact, magnets and armatures attract equally both when in contact and at a distance.

(10.) The attraction is proportional to the square of the number of windings of the electro-magnetic spirals.

(11.) The attractions are proportional to the squares of the magnetizing currents.—(Law of Lenz and Jacobi.)

(12.) The attraction increases with the proximity of the whole number of spiral windings to the surface of contact, up to a certain limit. This limit lies very near the surface of contact.

(13.) The attraction increases more when the spiral remains the same and only the iron core is made longer, than when in making the core longer the same number of windings is spread out over the whole length of the core.

(14.) With the same magnitude of contact surface, the attraction remains the same at a distance, when it is the same while in contact, whatever form the magnet and armature may have.

(15.) The attraction remains the same when the diameters of the magnet and armature are interchanged.

(16.) The attraction remains the same when the armature is made the magnet and the magnet the armature, (provided that the spiral, with the same galvanic effect, surrounds the iron core throughout its whole length.)

(17.) In different systems of equal length and equal diameter, the maximum attraction takes place when the armature and the magnet are of equal length.—*Pogg. Ann.*, lxxx, lxxxi, 494, 46.

4. *On the Amid compounds of Cyanogen.*—Cloez and Cannizzaro have studied the products of the action of gaseous chlorid of cyanogen upon ammonia. When the chlorid is passed into an ethereal solution of the alkali, chlorid of ammonium is formed and separated, while a new substance remains in solution, and may be obtained by distilling off the ether in a water-bath. This new substance the authors term Cyanamid, and as thus prepared it is a white crystalline body, fusing at 40°, but sometimes remaining liquid much below that temperature, in this case however, it instantly solidifies on being touched with a pointed glass rod; its formula is $Cy\,NH_2$. Heated to 150°, cyanamid presents a remarkable phenomenon; the fused mass suddenly solidifies with ev olution of great heat; the new substance thus produced, possesses the same constitution as cyanamid itself, but its properties are different and so strongly resemble those of melamine that the authors are disposed to regard it as identical with this substance, and consequently to

consider melamine as the amid of cyanuric acid, so that it results simply from tripling the equivalent of cyanamid; its formula should then be $Cy_3 (NH_2)_3$. Cyanamid is inalterable in dry air; water dissolves it readily, but if the solution be evaporated a residue is obtained nearly insoluble in water and apparently identical with cyanuramid; cyanamid is also soluble in alcohol and ether without change, but alkalis decompose it; with acids it gives crystalline compounds not yet examined. The volatile bases of Wurtz, and many other organic alkalies yield similar compounds when treated with chlorid of cyanogen; the authors have obtained cyano-methylamid, cyanethylamid, and cyanamylamid, represented by the formulas, $Cy\ C_2H_4N$, $Cy\ C_4H_6N$, $Cy\ C_{10}H_{12}N$. The properties of these substances are not yet described, neither is it stated whether there exists a class of isomeric cyanuramids as would appear highly probable.—*Comptes Rendus*, xxxii, 62.

5. *On Cinchonine.*—The constitution of cinchonine has been so differently represented by different chemists as to render it probable that these differences had their origin in an actual diversity of chemical constitution in different specimens of the alkali. Hlasiwecz has carefully investigated the whole subject anew and has found that commercial cinchonin contains two different substances which may be separated from each other by repeated crystallization. The first of these substances possesses all the properties of what is usually described as cinchonine: it crystallizes in moderately large prisms, yields chinolin by distillation, and partially sublimes as a crystalline wool: its formula was found to be $C_{40}H_{24}N_2O_2$, which is the formula given by Regnault. The platinum salt of this base is however represented by the formula $C_{38}H_{22}N_2O_2H_2Cl_2+2Pt\ Cl_2$, according to which it must have lost the elements of C_2H_2; the crystals obtained by sublimation have the same formula. The second substance crystallizes from the mother-liquor of the cinchonine in beautiful rhomboidal crystals; on heating, these become opaque and fuse to an amorphous mass, but do not sublime; analysis gave the formula $C_{20}H_{12}NO_2$, which is the same as that of β chinin found by Heijningen in commercial chinoidine: the author terms this base cinchotin. Commercial cinchonine contains also a brown basic resin which appeared to be identical with chinoidine; a second variety of commercial cinchonine gave the formula originally proposed, by Liebig, $C_{20}H_{11}NO$.—*Ann. der Chemie und Pharmacie*, lxxvii, 49.

6. *Aldehyde of Caprinic Acid.*—Wagner has studied the action of ammonia upon the oil of rue, which the researches of Gerhardt and Cahours had shown to consist principally of an oxygenated oil having the formula $C_{20}H_{20}O_2$ and capable of being readily converted by oxydation into caprinic acid, $C_{20}H_{20}O_4$. When oil of rue is dissolved in alcohol, and a current of ammonia passed into the solution, a white crystalline substance is obtained which exists only at low temperatures and at 0° is resolved into ammonia and oil of rue. Wagner considers this substance to be homologous with aldehyd-ammonia and to have the formula $C_{20}H_{20}O_2, NH_3$. When the new aldehyd-ammonia thus formed is dissolved in alcohol, a current of sulphurous acid passed through the solution, and the whole exposed to a low temperature for several days, a voluminous mass of crystals is obtained resembling margaric acid; these crystals are insoluble in water, soluble in boiling alcohol,

and decomposed by a gentle heat. The author regards this compound as homologous with Redtenbacher's bisulphite of aldehyd-ammonia, and as having the formula $C_{20}H_{20}O_2, NH_3+2SO_2$. Indications of the existence of a homologue of thialdin were also obtained.—*Journal für praktische Chemie*, 1851. l, 43.

7. *Theory of the formation of Ether.*—At the late meeting of the British Association at Edinburgh, a paper was read by A. Williamson upon this subject which deserves particular attention. When the compound of ether and potash, C_4H_5O+KO, obtained by treating absolute alcohol with potassium is gently warmed with iodid of ethyl, iodid of potassium and *ether* are formed, the reaction being represented by the equation,

$$C_4H_5O, KO+C_4H_5I=KI+2C_4H_5O.$$

If in place of iodid of ethyl, iodid of methyl be employed, a similar reaction takes place and a liquid is obtained having the empirical formula, $C_6H_8O_2$: iodid of amyl in like manner yields a new liquid boiling at 110° C., and represented by the formula $C_{14}H_{16}O_2$. Williamson considers these new liquids as alcohols and employing Gerhardt's notation, represents the former by C_3H_8O, the latter by $C_7H_{16}O$. The formation of common ether in the reaction given above he explains by supposing that the true formula of wine alcohol is $C_2\,\frac{H}{H}\,{}^5\,O$, of its potash compound $C_2\,\frac{H}{K}\,{}^5\,O$, and that ether results simply from the substitution of one eq. of ethyl for one eq. of hydrogen or potassium, the eq. of oxygen being the same in water, alcohol and ether. Pursuing this idea still farther, Williamson has succeeded in obtaining several other compounds analogous to those already mentioned, and has shown that the order of replacement is indifferent, since alcohol with iodid of methyl yields the same liquid as wood-spirit with iodid of ethyl. The physical and chemical properties of the new liquids are to form the subject of a special memoir; the author contents himself at present with applying the facts already ascertained to the explanation of the formation of ether by the action of sulphuric acid upon alcohol. In order to do this it is in the first place assumed that the formation of sulpho-vinic acid, $C_4H_5O.\,SO_3+HO.\,SO_3$, always precedes that of ether and that sulpho-vinic acid is formed by the replacement of one atom of hydrogen in sulphuric acid by one atom of ethyl; in the author's notation, $SO_4\,\frac{H}{H}+C_2\,\frac{H}{H}\,{}^5\,O=SO_4\,C_2\,\frac{H}{H_5}+\frac{H}{H}O.$ The formation of ether then ensues simply by the substitution of one atom of ethyl for one of hydrogen precisely as in the case of the potash compound above mentioned, we have namely the equation

$$\frac{C_2\,\frac{H}{H_5}\,SO_4}{C_2\,\frac{H}{H_5}\,O}=\frac{\frac{H}{H}\,SO_4}{\frac{C_2\,H_5}{C_2\,H_5}\,O}$$

The sulphuric acid thus set free acts upon a new portion of alcohol to form sulpho-vinic acid and thus the process is continuous. The formation of ether by the action of chlorid of zinc upon alcohol may

be explained in a similar manner.—*Phil. Mag.* [3], xxxvii, 350, and *Ann. der Chemie u. Pharmacie, Jan.*, 1851, lxxvii, 37.

[NOTE.—According to the theory of the constitution of alcohol now almost universally adopted by chemists, the results obtained by Williamson are to be explained by supposing that one eq. of oxyd of ethyl is capable of uniting with one eq. of oxyd of methyl to form a compound in which one of these two oxyds performs precisely the same function as the water in ordinary alcohol. The formula of the new substance must therefore be $C_4H_5O+C_2H_3O$. Williamson considers it inconceivable that the replacement of one eq. of hydrogen in wine alcohol by one eq. of ethyl should give rise to ether, if we admit that alcohol consists of ether in combination with water, and in support of his position he urges that the replacement of the same eq. of hydrogen by an eq. of methyl ought to yield simply a *mixture* of the oxyds of ethyl and methyl and not a chemical combination of the two. This argument falls to the ground, however, when we consider that *difference* in the bodies combining is absolutely essential for *chemical* combination, and that we know of no one instance in which two molecules of the same kind unite chemically; it is therefore easy to see why two molecules of ether brought under favorable circumstances into contact with each other, unite mechanically. The numerous cases of isomerism with which we are acquainted do not furnish arguments in favor of Williamson's position; we have no reason to suppose that cyanuric acid, for example, is a chemical compound of three equivalents of cyanic acid. It can hardly be doubted, however, that the replacement of hydrogen by organic radicals in the manner described will lead to the discovery of the true molecular structure of a vast number of organic compounds which have hitherto baffled investigation. The acetone series for example may possibly prove to be aldehydes in which an eq. of hydrogen is replaced by an eq. of methyl, ethyl or other similar radical; common acetone may perhaps be aldehyde in which an eq. of hydrogen is replaced by an eq. of methyl, and may be obtained by the reaction expressed by the equation $C_4H_4O_2+C_2H_3I=C_6H_6O_2+HI$. W. G.]

8. *On the theory of anisol and its homologues.*—The researches of Williamson on the replacement of the hydrogen of the alcohols by the radicals methyl, ethyl, amyl, &c., have led Cahours to examine the action of the iodids of these radicals upon the compound of potash and oxyd of phenyl represented by the formula $C_{12}H_5O+KO$. When phenol-potash and iodid of methyl are exposed together in a sealed tube to a temperature of from 100° to 120°, double decomposition occurs and the results are iodid of potassium and *anisol*. The reaction in this case is represented by the equation

$$C_{12}H_5KO_2+C_2H_3I=C_{14}H_8O_2+KI.$$

With iodid of ethyl and phenol-potash a similar reaction occurs and phenetol is formed; with iodid of amyl a new compound is formed which the author terms phenamylol. The formation of phenetol and phenamylol may be represented by the equations

$$C_{12}H_5KO_2+C_4H_5I=C_{16}H_{10}O_2+KI$$
$$C_{12}H_5KO_2+C_{10}H_{11}I=C_{22}H_{16}O_2+KI.$$

Phenamylol is a limpid colorless liquid, lighter than water, having an agreeable aromatic odor and boiling at 224°–225°: nitric acid readily attacks it and transforms it into a heavy oil, which by the action of an alcoholic solution of sulphid of ammonium yields a new base which the author calls phénamylidine nitrique.—*Comptes Rendus*, xxxii.

NOTE.—From the investigation of Cahours it appears evident that anisol is to be regarded as phenol in which one eq. of hydrogen is replaced by one eq. of methyl, or more correctly as a compound of oxyd of phenyl and oxyd of methyl, $C_{12}H_5O+C_2H_3O$. This fully explains the remarkable fact to which Kolbe* has directed attention, that the boiling point of anisol is lower than that of phenol with which it appears to be homologous. It also explains why anisol, which possesses the constitution of the alcohol of benzoic acid, does not yield this acid when treated with oxydizing agents. The writer of these notices had, long before the appearance of Cahours' researches, unsuccessfully attempted the production of benzoic acid by the oxydation of anisol; the cause of his failure is now evident; the true homologue of phenol, the alcohol of benzoic acid, remains to be discovered. W. G.

II. MINERALOGY AND GEOLOGY.

1 *Notices of Minerals and new localities;* by Prof. O. P. HUBBARD, Dartmouth College. (Communicated for this Journal.)—(1.) *A large group of Quartz crystals*, now in Dartmouth College cabinet, was obtained many years since, from a cavity in the quartzite of Moose mountain, seven miles east from the college. It is fourteen inches high and wide and two feet long. The crystals are clear and vitreous, though not transparent. Some of the vertices were injured by the iron bar in extracting the mass. There are forty-eight crystals, some of which are six inches long, and they have the following dimensions.

4	crystals	each	5 to 5½		inches	in diameter.
10	"	"	4 " 4¾		"	"
12	"	"	3 " 3½		"	"
7	"	"	2 " 2¾		"	"
5	"	"	1 " 1¾		"	"
10	"	"	¾		"	"

(2.) *Quartz* in prismatic crystals with double pyramids from one to three inches long, and half an inch and more in diameter, are found in Benton, N. H., near Amos Wheeler's, on a mountain belonging to Daniel Howe. They occur abundantly in the earth where a vein has decomposed. Mr. Amos Wheeler speaks of "a vein of crystals two feet wide in limestone?" from which he brought me handsome implanted crystals though in a different gangue, and he describes a vein of black crystals near by.

(3.) Another locality of *quartz* is Mr. Ball's farm, Beaver meadow, Sharon, Vt.

Here the crystals are dug from the loose soil. They are beautifully clear and transparent, with one perfect termination only, the crystals

* Ann. der Chem. u. Pharmacie, lxxvi, 61.

having been obviously implanted by the other. One of the specimens I have seen is six inches long by two and a half inches diameter.

(4.) *Gray Staurotide* in crosses at 90° and imperfect prisms occurs abundantly in light colored mica slate, in Grantham, about two miles from Meriden village.

The single crystals have a dark red rhombic center, surrounded by a gray exterior, and the angles of the inner and outer prisms do not agree in quantity.

Staurotide, Grantham, N. H.

The compound crystals have a composition like fig. 2 in Dana's Mineralogy, with a modification only on the obtuse solid angles.

(5.) *White Staurotide*, with similar modifications, has been brought me from an unknown locality.

(6.) *Chrysoberyl.*—This rare mineral occurs in the granite of Orange summit, at the deep cut of the Northern Railroad, in a very thin vein. A few specimens were found in the fragments of rock thrown out in making the cut. The forms are like the compound varieties figured in Dana's Mineralogy from Haddam, though without regular terminations.

(7.) *Beryl from Acworth.*—This crystal in the College cabinet has no peculiar beauty to distinguish it from other large specimens from the same locality, but it is remarkably regular in its hexagonal form, and also in size. Its diameter is 13¾ inches; height 14 inches; weight 114 lbs., or 96 lbs. to the foot of length, and thus larger than any other reported in the country. Another prism of a somewhat triangular form which I obtained from Grafton, is 16 inches in diameter.

(8.) *Kyanite from Thetford, Vt.*—On the road from the Ompompanoosuc river, north, along the east side of Thetford hill, kyanite occurs in veins or beds of quartz in mica slate, running parallel with the strata which dip west. At the surface the kyanite is reduced to very thin layers of little value, appearing as if the veins with the rock had been much abraded. Large grouped bladed crystals of fine blue and white colors, in specimens 16 inches across, were obtained from loose masses.

(9.) *Chrysolite.*—I am able to announce to mineralogists the discovery of this mineral in masses several inches in diameter. This is believed to be the first notice of its occurrence in North American mineralogy, east of the Rocky Mountains, and a more complete account will be given in a future number of this Journal.

Minerals from India.—(1.) *Apophyllite.* From Rev. Mr. Burgess, Am. missionary at Ahmednugger, India, I have received unusually large crystals of Apophyllite an inch in diameter, with the terminal solid angles deeply replaced.

(2.) *Natrolite* from the same region, in hemispheres seven inches in diameter, also in sectors of three inches radius and of the most beautiful lustre and whiteness.

(3.) *Quartz*, also, with the two last from the trap of the Deccan. The specimen is a stalactite three inches in diameter with a chalcedonic center, having the exterior entirely covered with crystals of quartz terminating in 3-sided pyramids.

Hanover, New Hampshire.

2. *Boulders Carried by Ice*, (Perley's Report on the Fisheries of New Brunswick, p. 26).—Off the western part of Shippagan Island, within the Bay of Chaleur, there is an extensive shallow flat, extending nearly two miles from the land, called the *Grand Batture*. On this flat, there are numerous large blocks or boulders firmly imbedded, which render it dangerous to cross, even with a fishing boat; the wreck of a fishing boat was noticed upon it when the writer crossed in his canoe. These boulders are brought over from the wild and mountainous shores of Caspe, directly across the bay, by the huge masses of floating ice, driven over by the northerly gales which ground upon the *Grand Batture*, and there melting, add the rocks they bring, to those already deposited. With reference to this moving of rocks by ice, Mr. Wilson mentioned that there was formerly a very large rock directly in front of his landing place, at Miscow, which was much in the way of his boats, and against which, in stormy weather, they had often received damage. But the severe winter of 1848–49, caused the ice to attain an unusual strength and thickness near the shore of Miscow: and when it moved off in the spring, it carried off this large rock to deposit it where, he hoped, it would be less troublesome.

III. Zoology.

1. *On the Classification of the Maioid Crustacea or Oxyrhyncha*; by James D. Dana.—The Maioidea are usually divided into three tribes, characterized by the relative lengths of the legs, viz., the *Macropodinea*, the *Maiinea*, and the *Parthenopinea*. A character of the kind here alluded to is of little importance as a distinction in classification, unless it is indicative of other more fundamental differences. The third of these subdivisions seems to be properly and distinctively a natural group. But the first two are essentially identical in all points, excepting the greater or less elongation of the eight posterior legs. The mouth, the antennæ, eyes, branchiæ, and other parts, afford no ground for separating them: moreover, the transitions are gradual and numerous. Libinia and Doclea pass into one another through Libidoclea, and these three genera are more closely related than Doclea and Inachus. Eurypodius contains a species with short legs; and the genus Oregonia, very near Eurypodius, has no longer legs than some of the admitted Maiinea. The mere length of the legs, if regarded, thus breaks up true natural groups.

De Haan sustains the separation of the Inachidæ (Edward's Macropodinea, Doclea and Latreillia being excluded,) on other grounds, acknowledging the unimportance of the characteristic derived from the legs. As in other departments of Crustacea, he basis his distinctions mainly on the maxillæ or maxillipeds. Thus his Maia, Pisa and Doclea groups include species having the fourth joint of the outer maxillipeds articulated with the inner apex of the third joint; while in his Inachus group, the articulation is with the summit of the third joint. This distinction would separate the intimately related genera Eurypodius and Oregonia, as this joint in the latter has the ordinary Maia form. On examining Eurypodius it is found that the peculiarity of the third joint referred to arises simply from its being lengthened or extended along the inner

side, so that the true apical margin slopes backward and outward. The fourth joint is articulated with the same part normally in both, and the only difference is in the greater or less inclination of the summit margin, when greatest it approximating to longitudinal. The little importance of the distinction based upon the maxillipeds among the Cancroidea as well as Maioidea is shown by numerous instances. Even the single genus Xantho presents wide variations, as the joint may be either transverse or oblong. (Compare Xantho Orbignii, *Edw.* with other species.) The system of De Haan for this reason, although developing some new relations, contains many ambiguities and incongruous associations, notwithstanding the learning of its author, the remarkable skill and accuracy of his work, and the vast additions of facts he has made to the science. We have admired the wonderful fidelity of his plates, the thorough spirit of investigation displayed through his magnificent volume, and the judgment with which he has seized upon typical forms in instituting his genera. Yet we can not but object to his defective system of arrangement and description, by which his types are often thrown into wrong associations, and the groups they typify are laid down with false limits,—the characters to be derived, (as the system of Milne Edwards illustrates,) from organs of real importance in the species, being sacrificed in a great degree to indications from the maxillæ or maxillipeds.

In the distribution of the Maioidea, we disregard, for the reasons stated, the older subdivisions of Macropodinea and Maiinea, and arrange their species into families and subfamilies as below, according to the characters of the eyes, antennæ and other organs, using these characters, in the order, as far as we can judge, of their relative bearing upon the functions or habits of the species.

De Haan has separated on good grounds *Latreillia* from the other genera, having shown that the posterior legs are short, dorsal, and more or less prehensile, as in Dromia, and that the vulvæ have the same position as in that genus (in the base of the feet of the third pair); and he therefore places the genus in the Dromia group. Still, in the number of branchiæ and some other characters, it is like the Maiinea, and it is properly an intermediate type. The outer antennæ are peculiar in being free and cylindrical from the very base, with the second joint much longer than the first, nearly as in the Dromiacea. These last facts with regard to the antennæ are also true of another genus having the posterior legs prehensile, somewhat Dromia-like, although they are not at all dorsal and also resemble the preceding legs. The genus referred to is *Oncinopus* of De Haan. It is apparently intermediate in character between the Maia tribe and Latreillia.

The aberrant form, Oncinopus, (and also Latreillia, if it be not thrown with the Dromiacea,) will naturally belong to a distinct group, and we therefore divide the Maioid Crustacea into three tribes, MAIINEA, ONCININEA and PARTHENOPINEA.

The Parthenopinea have the basal joint of the outer antennæ usually filling a hiatus in the orbit, as in most Cancroidea, and not projecting beyond the eyes, besides being more inward and posterior in position, and free or bounded laterally by sutures; while in the Maiinea this joint lies directly below the eye, projects beyond it, and is commonly soldered to the shell outside of the joint. The Parthenopinea are thus intermediate

between the Maiinea and the Cancroid Crustacea, resembling the latter also in their short epistome. The greater length of the anterior legs is not a necessary characteristic. They are also intermediate between the Maiinea and Dromioid species. The genus Trichia, of which De Haan makes one of his grand divisions of the Brachyura, is most nearly related to the Parthenopinea—the orbits, and antennæ, epistome and general form of the body resembling the same in Parthenope. But in its maxillipeds it approaches Dromia, as shown by De Haan.

Telmessus of White appears to belong with the Corystoidea, as the outer antennæ, in connection with the form, indicate.

The following are the Families, Subfamilies and Genera of MAIINEA with their characteristics:

FAM. I. MAIIDÆ.

OCULI RETRACTILES, IN ORBITIS SESE LATENTES.

1. DIGITI ACUMINATI.

A. Carapax oblongus.

a. OCULI PLUS MINUSVE TRANSVERSIM PORRECTI.

α ANTENNÆ EXTERNÆ APERTÆ.

* *Rostrum sive elongatum sive breve, porrectum, non tumidum.*

† Pedes 8 postici prælongi.

1. INACHINÆ.—Carapax triangulato-ovatus. Rostrum emarginatum aut integrum.

G. 1. INACHUS, *Fabricius.*—Carapax gibbosus, spinâ præorbitali sive parvulâ sive nullâ, rostro brevi. Pedes 8 postici filiformes, 2dis 3-4-plo longioribus quam carapax post-rostralis.

G. 2. EGERIA, *Latreille.*—Carapax gibbosus, orbiculato-ovatus, rostro sat brevi, paulo reflexo. Pedes 8 postici filiformes longissimi (iis *Inachi* duplo longiores).

G. 3. MICRORHYNCHUS, *Bell.**—Carapax gibbosus, latitudine transorbitali parvâ, dente præorbitali nullo, post-orbitali parvulo. Rostrum parvulum, integrum. Pedes 8 postici corpore fere duplo longiores.

2. MACROCHEIRINÆ.—Carapax latè ovatus. Rostrum furcatum. Pedes prælongi. Articulus antennarum externarum 1mus solutus.

G. MACROCHEIRA, *De Haan.*†—Carapax gibbosus, orbiculato-ovatus, spinâ præorbitali parvulâ, rostro saliente, cornubus valde divaricatis. Pedes toti validi longi.

†† Pedes 8 postici longitudine mediocres.

† *Pars antennarum externarum mobilis margine orbitæ orta.*

3. MAIINÆ.—Carapax orbiculato-ovatus, rostro prominente, profundè bifido.

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* Zool. Trans., ii, 40. † Crust. Fauna Japonica, 88.

G. Maia, *Lamarck.*—Articulus antennarum ext. 1mus spinis duabus longis apicem externum armatus. Spina inter-antennalis elongata, acuta. Tarsus infra non spinulosus.

‡‡ *Pars antennarum externarum mobilis orbitâ omnino exclusa.*

4. PISINÆ.—Carapax triangulato-ovatus, rostro bifido.

1. Pedes 8 postici non valde compressi; articulus 5tus processu infra non armatus.

G. 1. Paramithrax, *Edwards.*—Carapax gibbosus, rostro elongato. Oculi graciles. Articulus antennarum externarum 1mus spinis duabus longis apicem externum armatus (eoque *Maiæ* affinis).

G. 2. Pisa, *Leach.*—Carapax elongatè pyriformis, gibbosus, spinâ præorbitali saliente, rostro longo, vix depresso. Articulus antennarum ext. 1mus angustus. Pedes 2di 3tiis valde longiores.

G. 3. Pelia, *Bell.**—Carapax elongatè pyriformis, gibbosus, spinis præorbitali et post-orbitali carens, rostro longo, vix depresso. Articulus antennarum ext. 1mus angustus. Pedes 1mi 2dis breviores.

G. 4. Lissa, *Leach.*—*Pisæ* affinis. Carapax pyriformis, rostro longiusculo, cornubus laminatis, truncatis, dente præorbitali saliente.

G. 5. Rhodia, *Bell.*†—Carapax pyriformis, paulo depressus, spinâ præorbitali saliente, rostro brevi, acuto. Articulus antennarum externarum 1mus angustus, apicem acutè productus extus unidentatus. Pedes 1mi 2dis breviores.

G. 6. Hyas, *Leach.*—Carapax ovatus, sæpe lyratus, depressus, spinâ præorbitali carens, rostro longiusculo, acuto, depresso. Articulus antennarum ext. 1mus angustus, 2dus depressus, tarsus infra non spinulosus.

G. 7. Pisoides, *Edw.* et *Lucas.*‡—*Hyadi* affinis. Carapax latè ovatus, spinâ præorbitali carens, postorbitali parvâ, rostro longiusculo, acuto. Articulus antennarum ext. 1mus latissimus, 2dus depressus, densè ciliatus.

G. 8. Herbstia, *Edwards.*—Carapax orbiculato-ovatus, depressus, spinâ parvâ præorbitali instructus, rostro brevi, cornubus paulo depressis acutis. Articulus antennarum ext. 1mus angustus, apicem acutè productus, extus uni-dentatus. Pedes 1mi 2dis longiores.

2. Pedes 8 postici late compressi.

G. 10. Thoe, *Bell.*§—Carapax late ovatus, rostro parvulo, bifido, dente præorbitali saliente. Oculi breves. Articulus antennarum ext. 1mus latissimus. Pedes 1mi *maris* 2dis longiores.

3. Articulus pedum posticorum 5tus processu infra armatus.

G. 11. Dehaanius, *M'Leay.*‖—*Hyadi* paulo affinis. Carapax latus, spinâ præorbitali saliente, rostro sat brevi. *Leucippæ* affinis, si oculi non retractiles.

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* Zool. Trans., ii, 35.
† Zool. Trans., ii, 43.
‡ Crust. D'Orbigny's South America 10, pl. 5. The species P. tuberculosus appears to be the Hyas Edwardsii of Bell, Zool. Trans. ii, 49.
§ Zool. Trans. ii, 47.
‖ M'Leay, Smith's Illust. Zool. S. Africa.

** *Rostrum saliens, porrectum, tumidum, apice emarginatum.*

5. LIBININÆ.—Carapax latè pyriformis, tumidus, lateribus altis. Oculi perbreves. Pedes sive mediocres sive prælongi.

G. 1. LIBINIA, *Leach.*—Pedes mediocres. Carapax dente præorbitali parvulo instructus. Abdomen *maris feminæque* 7-articulatum. Articulus antennarum ext. 1mus latiusculus, extus non dentigerus.

G. 2. LIBIDOCLEA, *Edw.* et *Lucas.**—Pedes longi. Carapax spinis plus minusve armatus, dente præorbitali parvo. Articulus antennarum ext. 1mus angustus, apicem acutè productus, extus dentigerus.

G. 3. DOCLEA, *Leach.*—Pedes prælongi. Carapax spinis plus minusve armatus, dente præorbitali carens. Articulus antennarum ext. 1mus angustus, abdomen *maris* 7-articulatum, *feminæ* 5–7-articulatum.

*** *Rostrum breve, latissimum, bilobatum, porrectum.*

6. PRIONORHYNCHINÆ.—Carapax ovatus, gibbosus. Oculi breves, Fossæ antennales marginem frontalem fere attingentes.

G. PRIONORHYNCHUS, *Hombron* et *Jacquinot.*†

**** *Rostrum latum, valde deflexum.*

7. MICIPPINÆ.—

G. MICIPPA, *Leach.*—Oculi longiusculi. Carapax anticè parce angustior, rostro laminato.

β ANTENNÆ EXTERNÆ SUB ROSTRO CELATÆ.

8. CHORININÆ.—Carapax triangulato-ovatus. Rostrum furcatum. Pedes 8 postici vix compressi.

G. 1. CHORINUS, *Leach.*—Carapax gibbosus, spinis plus minusve armatus, rostro longo, cornubus acuminatis, spinâ præorbitali saliente. Margo orbitalis inferior largè interruptus. Articulus antennarum ext. 1mus angustus. Pedes 2di 3tiis valde longiores.

G. 2. CHORILIA, *Dana.*‡—Carapax formâ rostroque *Chorino* affinis. Orbita infra latè interrupta, supra fissa, spinâ præorbitali acutâ. Articulus antennæ externæ 1mus angustus, apice externo acutè producto. Pedes 1mi 2dis breviores, 8 postici similes, 2di 3tiis non multo longiores.

G. 3. LAHAINA, *Dana.*§—Carapax formâ rostroque *Chorino* plerumque affinis. Cornua rostri gracillima valde divaricata. Articulus antennæ externæ 1mus latus, parce longior quam latior, apice cum processu spiniformi armato. Orbita infra supraque sinu rotundato interrupta, dente præorbitali acuto. Pedes toti graciles.

G. 4. NAXIA, *Edwards.*—Carapax gibbosus, rostro mediocri, cornubus subcylindricis, truncatis, dente præorbitali brevi. Margo orbitalis inferior fissus, non late interruptus. Articulus antennarum ext. 1mus latus, apicem angustus.

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* Crust. D'Orbigny's South America, 6, pl. 3.
† Voy. Astrolabe et Zelée au pole Sud, pl. 1. f. 1.
‡ This volume, p. 269.
§ This volume, p. 269.

G. 5. Scyra, *Dana.**—Carapax gibbosus, rostro mediocri, laminato, cornubus acutis, dente præorbitali acuto. Margo orbitalis superior paulo unifissus. Articulus antennarum ext. 1mus omnino angustus, 2dus depressus.

G. 6. Hyastenus, *White.*†—*Chorino* affinis. Rostrum prælongum, cornubus non depressis, ante poneque oculos directus. Margo orbitalis superior unifissus. Pedes 2di longiores.

9. PYRINÆ.—Carapax subpyriformis. Pedes 8 postici valde compressi.

G. 1. Pyria, *Dana.*—Carapax depressus, inermis, rostro lamellato, cornubus ovatis. Oculi perbreves, orbitâ spinis non armatâ.

b. OCULI LONGITUDINALITER PORRECTI, CARAPACE ANTICE TRUNCATO.

10. OTHONINÆ.—Carapax antice late truncatus, rostro fere obsoleto. Oculi elongati, cylindrici.

G. Othonia, *Bell.*‡—Carapax parce oblongus, suborbicularis, rostro bifido. Antennæ internæ minutissimæ; externæ latæ, articulo 1mo lato, 2do valde depresso, inverso-subtriangulato.

B. Carapax paulo transversus.

81. SALACINÆ.—Carapax fere orbicularis. Pedes 8 postici crassi, longi, articulo penultimo infra recto. Rostrum fere obsoletum integrum.

G. Salacia, *Edwards* et *Lucas.*§—Carapax gibbosus. Fossa antennalis sub rostro partim excavata. Articulus maxillipedis externi 3tius medio apice emarginatus, hocque emarginatione articulum proximum gerens. *Inacho Grapso*que affinis.

2. DIGITI APICE OBTUSI, INSTAR COCHLEARIS EXCAVATI.

12. MITHRACINÆ.—Oculi mediocres. Carapax sive paulo oblongus, sive transversus.

G. 1. Mithrax, *Leach.*||—Carapax sæpe orbiculato-ovatus, interdum transversus. Rostrum aut saliens aut fere obsoletum, bifidum. Articulus antennarum ext. 1mus apicem externum duabus spinis longis armatus.

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* This volume, p. 269.

† Ann. Mag. Nat. Hist. [2], xx, 61, and Crust. Voy. of Samarang, p. 11. The species is Seba's fig. 12, pl. 18 of the Thesaurus.

‡ Zool. Trans., ii, 55.

§ Crust. in D'Orbigny's S. Amer., 12, pl. 11.

|| The characters given by White for his genus *Schizophrys* (Ann. Mag. N. H. [2], ii, 282, 283, and Voy. Samarang, Crust., p. 16) do not serve to exclude the species from Paramithrax, Maia or Mithrax. The peculiarity of the orbit described and of the 1st joint of the outer antennæ, as far as understood by the writer from the description, are the same as in the genera just mentioned.

The genus *Dione* of De Haan (Fauna Japon. Crust. p. 82,) differs from Mithrax only in not having the interior apex of the third joint of the outer maxillipeds project inward a little over the insertion of the fourth joint. It corresponds to "*Mithrax triangulaires*" of Edwards.

G. 2. MITHRACULUS, *White.*—Carapax transversus. Articulus antennarum ext. 1mus duabus spinis longis non armatus.

13. CYCLACINÆ.—Oculi longi.

G. CYCLAX, *Dana.**—Carapax paulo oblongus, orbiculato-ellipticus, rostro sat brevi, bifido, acuto. Pedes 8 postici longi.

FAM. II. TYCHIDÆ.

OCULI RETRACTILES, SUB CARAPACE LATENTES, ORBITIS CARENTES.

1. CRIOCARCININÆ.—Rostrum valde deflexum. Carapax oblongus.

G. CRIOCARCINUS, *Guerin.*—Oculi prælongi, orbitæ margo superior processu longo lamellato apicem armato instructus.

2. TYCHINÆ.—Carapax oblongus, anticè latus, latitudine trans-orbitali grandi, rostro non deflexo, sat longo, furcato. Oculi apice paululum exserti.

G. TYCHE, *Bell.**—Carapax depressus, anticè cornubus rostri spinisque duabus præorbitalibus totis parallelis et subæquis confectus, spinâ post-orbitali nullâ. Articulus antennarum ext. 1mus oblongus, inermis.

3. CAMPOSCINÆ.—Carapax oblongus, rostro fere obsoleto, emarginato. Pedes 8 postici longi. Oculi longè pedunculati et exserti.

G. CAMPOSCIA, *Latreille.*—Carapax subpyriformis, non armatus. Pedes 8 postici subcylindrici, 2di 3tiis breviores.†

FAM. III. EURYPODIDÆ.

OCULI RETRACTILES, NON SESE LATENTES.

1. *Antennæ externæ apertæ.*

1. EURYPODINÆ.—Carapax triangulato-ovatus, rostro longo, furcato. Pedes longi, 4 postici non bene prehensiles. Oculi longi et longe salientes. Spina post-orbitalis oblonga.

G. EURYPODIUS, *Guerin.*—Pedes 8 postici longi, articulo penultimo valde compresso, ensiformi.

G. OREGONIA, *Dana.*‡—Pedes 8 postici sat longi, articulo penultimo subcylindrico.

2. *Antennæ externæ sub rostro celatæ.*

AMATHINÆ.—[An oculi retractiles, iis *Eurypodii* similes, eoque genus hac sede?] Carapax triangulato-ovatus, rostro furcato, latitudine trans-orbitali perangustâ. Pedes longi.

G. AMATHIA, *Roux.*—Carapax gibbosus, valde armatus, rostro prælongo, cornubus divaricatis. Pedes filiformes, prælongi. Oculi parvi. Articulus antennarum ext. 1mus perangustus. Epistoma fere quadratum.

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* This vol., p. 269. † Zool. Trans. ii, 57. ‡ This vol., p. 270.

Fam. IV. LEPTOPODIDÆ.

Oculi non retractiles, sese non latentes. Pedes prælongi.

A. Antennæ externæ apertæ.

1. ACHÆINÆ.—Carapax triangulato-ovatus, rostro perbrevi, bifido. Oculi longi, longèque salientes. Pedes 4 postici subprehensiles.
   G. 1. Achæus, *Leach.*—Carapax gibbosus. Pedes 8 postici filiformes, longi, tarso pedum 4 posticorum falciformi, articulis penultimis subcylindricis.

2. INACHOIDINÆ.—Carapax triangulato-ovatus, rostro elongato, simplice.
   G. Inachoides, *Edw.* et *Lucas.**—Carapax valde gibbosus, rostro longiusculo, acuto, spinâ postorbitali parvâ. Pedes 8 postici sat longi, gracillimi. Articulus antennarum ext. 1mus angustus.

B. Antennæ externæ celatæ.

3. LEPTOPODINÆ.—Carapax triangulato-ovatus, rostro elongato, simplice. Pedes longissimi.
   G. Leptopodia, *Leach.*—Oculi sat salientes. Pedes toti gracillimi.

4. STENORHYNCHINÆ.—Carapax triangulato-ovatus, rostro breve, bifido.
   G. Stenorhynchus, *Lamark.*—Oculi sat salientes. Pedes antici crassiusculi.

Fam. V. PERICERIDÆ.

Oculi non retractiles, sese non latentes. Pedes longitudine mediocres.

A. Antennæ externæ apertæ.

1. PARAMICIPPINÆ.—Rostrum valde deflexum. *Micippæ* aspectu similes.
   G. Paramicippa.—Rostrum latum, articulus antennarum ext. 2dus breviter cordiformis. Epistoma perbreve.

2. PERICERINÆ.—Rostrum profundè bifidum, non deflexum.
   G. 1. Pericera, *Latreille.*—Carapax sæpe triangulatus, interdum orbiculato-ovatus, paucis spinis sæpius armatus, rostro divaricatè furcato. Articulus antennarum ext. 1mus apice latus et spinâ armatus. Orbita tubulata, oculum strictè includens, margine superiore subtiliter unifisso.
   G. 2. Tiarinia, *Dana.*†—Carapax subpyriformis, tuberculis plerumque pustuliformibus sæpeque aggregatis ornatus, rostri cornubus gracilibus contiguis. Articulus antennarum ext. 1mus apicem latus et inermis, angulo externo interdum saliente tantum.

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* Crust. in D'Orbigny's S. Amer., 4, pl. 4.

† This volume, p. 271.

G. 3. Perinia, *Dana.**—Carapax orbiculato-ovatus, tuberculis paucis non acutis ornatus, rostri cornubus brevibus, discretis. Articulus antennarum ext. 1mus oblongus, apicem non latior, angulo externo valde producto. Orbita anticè aperta, margine superiore non unifisso.

G. 4. Halimus, *Latreille.*—Carapax triangulato-ovatus, cornubus rostri grandibus, divaricatis. Articulus antennarum ext. 1mus angustus. Articulus pedum 8 posticorum 5tus valde compressus, processu infra non armatus.

G. 5. Pugettia, *Dana.*†—Carapax triangulato-ovatus. Rostro antennisque ext. *Halimo* affinis. Articulus pedum 8 posticorum 5tus cylindricus.

3. MENÆTHINÆ.—Rostrum integrum aut subintegrum.

G. 1. Menæthius, *Edwards.*—Carapax triangulato-ovatus, depressus, regione antero-laterali plicis tribus plus minusve ornatâ. Pedes 8 postici cylindrici. ‡

G. 2. Acanthonyx, *Latr.*—Carapax depressus, non tuberculatus, sive subtriangulatus sive subquadratus (dente post-orbitali dilatato), regionibus non conspicuis, dente præorbitali parvulo, rostro crasso, apice emarginato. Pedes 8 postici mediocres, articulo penultimo compresso, infra dilatato et sæpe dentigero.

G. 3. Antilibinia, *M'Leay.*§—Carapax valde convexus, regionibus non conspicuis, latitudine transorbitali minore (lat. max. 3plo latiore), rostro crasso, apice emarginato. Articulus pedum 8 posticorum penultimus infra non dilatatus nec dentigerus.

G. 4. Peltinia, *Dana.*‖—Carapax depressus vix tuberculatus, dente præorbitali breviter instructus, latitudine transorbitali majore (lat. max. 2plo latiore), rostro lato, profundè bifido, sat brevi. Articulus pedum 8 posticorum penultimus infra non dilatatus nec dentigerus.

B. Antennæ externæ sub rostro celatæ.

1. Oculi prælongi.

4. STENOCIONOPINÆ.—Rostrum longum, furcatum, cornubus styliformibus, divaricatis.

G. Stenocionops, *Latreille.*—Carapax subpyriformis, gibbosus, spinâ præorbitali longissimâ. Articulus antennarum ext. oblongus.

2. Oculi aut longitudine mediocres aut perbreves.

5. EPIALTINÆ.—Rostrum oblongum, crassum, sive integrum sive emarginatum. Antennæ ext. apicem rostri sæpius non attingentes. Pedes 8 postici subcylindrici.

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* This volume, p. 271. † Ibid, p. 268.

‡ The genus *Xiphus* of Eydoux and Souleyet, as figured in the plates of the Voyage of the Bonite, has the beak, præorbital spine or tooth, outer antennæ, and general form of Menæthius. But the eyes may be longer pedunculate, and as there is no description, it is not apparent whether they are retractile or not. The species is called *Xiphus margaritiferus*. The beak is pointed, and the 3d basal joint of the outer antennæ reaches to apex of beak.

§ Smith's Illust. S. Af. Zool. ‖ This volume, p. 272.

G. 1. Epialtus, *Edw.*—Carapax inermis, vix tuberculatus, regionibus non conspicuis. Octo pedes postici nudi aut subnudi, articulo penultimo infra sæpe subdentigero.

G. 2. Huenia, *De Haan.**—Carapax 2–4 tuberculis acutiusculis sæpius armatus, interdum inermis, regionibus inconspicuis, rostro simplice, angulo carapacis postero-laterali prominente. Articulus pedum 8 posticorum penultimus plerumque infra dilatatus, dentigerus.

G. 3. Xenocarcinus, *White.*†—Carapax tuberculis subacutis sparsim armatus, rostro simplice, truncato, margine postero-laterali non angulator, otundato.

G. 4. Leucippa, *Edw.*—Carapax subtriangulatus fere inermis, regionibus non conspicuis, spinâ præorbitali nullâ. Pedes supra carinati, articulo penultimo infra non producto. Dens post-orbitalis prope oculum insitus, oculum vero non celante.

Genus Zebrida, *White*,‡ incertæ sedis; antennis externis obitâque *Eumedono* similis, eoque Parthenopineis congruit.—Carapax depressus, non armatus antice latior, dente post-orbitali portentosè expanso, rostro latissimo, lamellato, profundè furcato. Oculi paululum salientes. Pedes compressi, angulati. Articulus antennarum externarum 1-mus *hiatum orbitæ occupans*, antice non productus.

2. *The Apteryx of New Zealand.*—With the skin of the *Notornis Mantelli* described in the January number of this Journal, xi, 102, Mr. Walter Mantell sent the skins of three birds of the genus Apteryx; one of them is the small and rare species figured and described in the Zoological Transactions of London, by Mr. Gould, as *A. Owenii*. The other skins were supposed to be of the common species, generally known as the *Apteryx australis;* of which some thirty or forty specimens have been sent to Europe, and are distributed in the public and private zoological collections of England and the continent. One of Mr. Mantell's specimens was remarkable for its large size, and short and strong legs; but though seen by many eminent ornithologists in London, it was regarded only as a very large and fine example of the common species, till Mr. Bartlett, the eminent taxidermist, in whose hands it was placed by Dr. Mantell to stuff and mount, compared it with the various specimens in the British museum, and in the collections of the Zoological Society, and ascertained that it was specifically distinct from that usually named the *Apteryx australis*. Mr. Bartlett therefore drew up a description of this bird to lay before the Zoological Society: but fortunately first applied to the Earl of Derby for the loan of the original specimen figured and described by Dr. Shaw, in 1812, and which at the death of that naturalist passed into Lord Derby's possession. Upon receiving this bird, Mr. Bartlett found that it was identical with the supposed new species sent home by Mr. Walter Mantell; the latter therefore is the true Apteryx australis of Dr. Shaw, and only the second example known in Eng-

* Crust. Faun. Japon. 73.

† Jukes's Voy. H. M. S. Fly; Ann. Mag. N. H. [2], i, 331; Crust. Voy. Erebus and Terror, pl. 2, fig. 1.

‡ Crust. Voy. of Samarang, p. 23.

land : the common species having been hitherto confounded with it, from no careful comparisons having been instituted with the original type. As the ordinary and smaller species is thus deprived of a specific name, Mr. Bartlett has given it that of *Mantelli* to commemorate the scientific researches of the young naturalist whose labors have so much extended our knowledge of the recent and extinct faunas of New Zealand. There are now however three species of this extraordinary "wingless" bird, viz., *Ap. australis*, *Ap. Owenii*, and *Ap. Mantelli*. It is probable that a fourth and much larger species still exists in the Middle Island. Mr. Bartlett's memoir on this subject will appear in the Proceedings of the Zoological Society of London. It is very probable that in some of the ornithological collections in this country—for example in that of the Academy of Natural History of Philadelphia—a specimen of the true *Ap. australis* may occur; having been mistaken for a large variety of the more common species, now the *A. Mantelli;* at all events we would recommend our scientific friends to examine the various examples of Apteryx in their collections with a view to this question. We may add that both Dr. Shaw's and Mr. Walter Mantell's specimens were from the Middle Island : the more abundant species is from the North Island.

3. *Ibis guarauna in New England;* by Dr. Cabot, (Proc. Bost. Soc. Nat. Hist., Nov., 1850, p. 313.)—*Ibis guarauna* has been confounded with *I. falcinellus* by many naturalists, among others even by Nuttal, Buonaparte, and Audubon. Lately our newspapers have contained several notices of some specimens of the Glossy Ibis which have been procured in different parts of this state, with various theories to account for their appearance in this part of the world, (such as, that they had passed round by Behring's Straits, &c.) all of which are absurd for several reasons: 1st. The bird is not the same as that found in the old world; it is larger. 2nd. The *I. falcinellus* is rare in the north of Europe as *I. guarauna* is here. 3d. Since the bird feeds on living animals and plants, it could not subsist on its voyage through the arctic regions at the early season at which it must have passed; it could much more easily have come straight across the ocean. 4th. We have a much more easy way of accounting for their appearance, namely, the *I. guarauna* (the bird which has been mistaken for *I. falcinellus*) is found in immense flocks in Mexico and in considerable numbers in Texas and Florida, where it breeds; so that, to account for their appearance here, we have only to suppose that a few wandered a couple of days' journey farther north than usual, as we know to have been the case occasionally with other southern birds, as the Martinico and Florida Gallinules, White Egret, Pelican, &c. During the present month, [June,] four specimens of the *I. guarauna* have been procured in the New England states, three of them in Massachusetts, of which one was shot by Mr. F. Brown on the Fresh Pond marshes, and by him presented to the Harvard Natural History Society, who with great liberality presented it to us. The other two are in the possession of Mr. Jenks, of Middleboro', where they were shot. One was procured in Middletown, Ct., and is in the possession of Dr. J. Barrett of that place. Nuttal says, that they are occasionally exposed for sale in Boston markets; probably at the time when he made this observation there

had been a flight of them into this state, similar to what has occurred this year; for during the past eighteen years (with the exception of three) Dr. Cabot had kept a very close watch upon our markets, with the express purpose of procuring birds for his own and the Society's collection, and in that time he had never seen a single specimen of this bird.

IV. Miscellaneous Intelligence.

1. *Abstract of Meteorological Observations made at Burlington, Vt., in* 1850; by Z. Thompson.—*Note.* The location is one mile from the shore of Lake Champlain, and 256 feet above the lake (346 above the sea) in lat. 44° 29′, and long. 73° 11′.

1850.	THERMOMETER.				BAROMETER.			
Months.	Mean	Highest.	Lowest.	Range.	Mean.	Highest.	Lowest.	Range.
	°	°	°	°	Inches.	Inches.	Inches.	Inches.
January, . .	23·74	46	−1	47	29·86	30·37	29·10	1·27
February, . .	24·32	54	−18	72	29·65	30·49	28·81	1·68
March, . .	30·47	49	0	49	29·68	30·26	29·17	1·09
April, . . .	41·02	76	17	59	29·65	30·09	28·98	1·11
May, . . .	51·64	75	33	42	29·60	30·00	29·00	1·00
June, . . .	67·13	93	46	47	29·69	29·99	29·41	0·58
July, . . .	70·04	89	47	42	29·69	29·98	29·33	0·65
August, . .	66·03	90	43	47	29·69	29·97	29·28	0·69
September, .	59·69	82	40	42	29·69	29·96	29·30	0·66
October, . .	48·25	70	28	42	29·62	29·95	29·09	0·86
November, .	40·38	62	26	36	29·72	30·05	28·99	1·06
December, .	18·65	46	−10	56	29·75	30·28	28·80	1·48
An. M.	45·14			111	29·69			1·69

1850.	WINDS.								WEATHER.		SNOW.	WATER.
Months.	N.	N. E.	E.	. E.	S.	S. W.	W.	N. W.	Fair.	Cloudy.	Inches.	Inches.
January,	8	1	2	3	10	2	1	4	13	18	16	1·57
February,	9	1	1	2	11	0	2	2	15	13	18	1·79
March,	13	1	0	1	8	1	5	2	20	11	12	1·11
April,	6	1	1	2	11	1	4	4	22	8	8	2·41
May,	6	2	2	4	10	2	3	2	18	13	0	5·04
June,	7	2	0	2	14	1	2	2	23	7	0	3·18
July,	9	0	0	2	16	1	1	2	23	8	0	5·08
August,	14	0	0	2	13	0	1	1	27	4	0	0·89
September	8	0	2	1	15	0	1	3	22	8	0	3·25
October,	7	0	0	1	15	1	1	6	17	14	5	8·11
November,	7	1	1	2	12	1	3	3	16	14	1	1·77
December,	11	2	2	1	11	0	1	3	14	17	48	3·31
	105	11	11	23	146	10	25	34	230	135	108	37·51

The results in the above tables are deduced from three daily observations made at sun-rise, 12 M. and 9 P. M. The warmest day in the year was the 19th of June, the mean heat of which was 82°; the coldest day was the 5th of Feb., the mean of which was −6°. The mean temperature of the year was 0°·23 warmer than the average of the twelve preceding years. The range of the thermometer was 6° less, and the range of the barometer 0·13 in. greater than in 1849.

The column of water includes the rain and melted snow; and the amount in 1850, was 5·3 inches greater than the average annual fall in the preceding twelve years, and was more than fell in any one of those years, excepting 1847, in which the fall was 38·55 inches.

The broad part of the lake opposite to Burlington, was not frozen over during the year, an occurrence which has been witnessed only three times in the last thirty-four years. During the year there were eighty-four days of tolerable sleighing in Burlington and vicinity.

The water of the lake was highest May 29, being then one foot ten inches below extreme high-water mark, and lowest Jan. 1, being five feet ten inches below high-water,—change of level of the lake in the year, four feet. The extreme change of level is about eight feet. A severe rain storm occurred on the 18th, 19th, and 20th of July—fall of water 3·62 inches—crops along the streams overflowed and nearly ruined—railroads and other roads much injured.

October 26 and 27, another severe rain storm terminating with a fall of five inches of snow—depth of water from rain and snow, 3·78 inches.

December 23, remarkable snow storm with high winds—twenty inches of snow, much drifted—roads nearly impassible for several days.

Barn swallows appeared May 2; currants blossomed May 13; plums and cherries, 20; Siberian crab-apple, June 2; common apple, June 4.

2. *Magnetic Observatory at Toronto.*—We are indebted to Prof. Henry for a copy of the following letter from the Hon. Abbot Lawrence, informing him of the decision of the Lords of the Treasury with regard to the continued support of the Toronto Observatory; a subject which deeply interested the members of the American Association at its last meeting at New Haven.—Eds.

"*My Dear Sir*,—I have the pleasure to inform you that I received a communication last evening from the Viscount Palmerston upon the subject of your letter addressed to me in October last, a copy of which I have transmitted to the Secretary of State, Mr. Webster—I also received a letter from the Secretary of the American Scientific Association which assembled last year at New Haven. You will oblige me by communicating the result of my application to this government to such persons as you may deem proper. I have known for several weeks that the Lords of the Treasury would continue the appropriation for the Observatory at Toronto. I had not however received the information in an official form till now.

I am, dear sir, most faithfully, your obedient servant,

Joseph Henry, Esq., Washington." Abbott Lawrence.

3. *African Geography;* (Proc. Geog. Soc., London, in Athenæum, No. 1217.—Two communications on African geography preceded the papers of the evening. In the first, mention was made of the successful ascent of the cataract of the White Nile which had stopped the further progress of D'Arnaud. The expedition, consisting of the missionaries, Dr. Knoblicher (Vicar), Don Angelo Binco, and Don Emanuel Pedemonte, started with seven vessels from Khartum, on Nov. 13, 1849. On the 14th Jan., 1850, the great cataract was for the first time prosperously ascended, under the guidance of their bold pilot Suleiman Abu Zaid, favored by a strong north wind. Immediately above the cataract, the navigation of the river was rendered extremely difficult by sand-banks, and higher up by rocks. At the village of Tokiman, the surprise of the natives at the sight of the vessels and of white men was amusing. The party arrived at Logwek on the 16th of January, where Dr. Knoblicher ascended a lofty granite hill, from the top of

which the White Nile could be seen stretching away to the southwest, and in the distant horizon the summits of a range of lofty mountains were distinctly traced. At the 4° of lat., the Nile was 200 yards broad, and from two to three deep.—In the second African paper, the Rev. D. Livingston communicated, through the London Missionary Society, an account of another large lake, 150 to 200 miles to the northwards of Lake Ngami, the discovery of which was announced last year, and for which Mr. Livingston received the second prize of the Society. The new lake contains large islands, on one of which Sebetoane, the well-known chief, resides. The two lakes are connected by a rapid stream, the Teoge. The inhabitants around this lake are said to be in communication with the Portugese settlements on the coast. Mr. Livingston intended proceeding again shortly to the north on a visit to the chief.

4. *The sources of the Nile;* (Athenæum, No. 1217.)—The *Times* of Saturday last contains a letter from a correspondent at Vienna, dated February 9th, from which the following is an extract :—

"As everything connected with the sources of the Nile is likely to prove interesting to the British public, I must not omit to inform you that I have to-day had an interview with Dr. Knoblicher, the Pope's Vicar-General in Central Africa, who, after having passed some years among the Maronites, in the Lebanon, founded an establishment at Khartum, at which city the main river separates into the White and Blue Nile. Along the former, the Rev. Doctor travelled to within 4 deg. 9 min. of the equator. He twice ascended a mountain called Logwek, in the latitude above mentioned, and saw the Nile trending away in a southwesterly direction, until it vanished between two mountains. The last natives he met with, the Bary negroes, informed him that beyond those mountains the river came straight from the south. The Nile was in 4 deg. 45 min. north latitude, 200 French mètres broad (about 625 English feet) and from three to five mètres deep. Dr. Knoblicher, a native of Laibach, in Carniola, and as a linguist a worthy disciple of Mezzofanti, is of opinion that the source of the Nile is to the south of the equator; and he is confirmed in this idea by the fact that the river was rising on the 16th of January, which he considers as a consequence of the rainy season having set in, in districts much farther south. Dr. Knoblicher left Khartum on the 13th of November, 1849, reached the country of the Bary negroes, whom he estimated at about 2,000,000, on the 16th of January, 1850, and arrived at Khartum again the 7th of March. The enterprising and intelligent traveller's journal is most interesting; with true German patience he has noted, frequently six times in an hour, all the changes in the direction of the river, the velocity of the current, the direction of the wind, the peculiarities of the vegetation, the appearance of the heavenly bodies, &c.; in short, everything which can possibly be of interest to scientific men. It was most interesting to see his reverence filling up the map of Africa published by the Society for the Diffusion of Knowledge agreeably to the surveys entered in his diary. The Austrian traveller will be with the Bary negroes again in November next, as he is determined to continue his researches. It was with a painful feeling that I learnt in the course of conversation that Dr. Knoblicher had not been able to go to

the expense of a chronometer before he started on his journey; he had a sextant, thermometer, barometer, &c., and 'Griffin's Practical Navigation,' but the great essential was and still is wanting."

The spot to which Dr. Knoblicher thus succeeded in penetrating is several miles higher up the stream than the extreme point reached, in 1841, by the second Turco-Egyptian Expedition sent by the late Mohammed Ali Pasha to discover the source of the Nile,—in which Expedition M. d'Arnaud and M. Werne took part; and the explicit information now furnished by him respecting the upper course of the river sets at rest the question as to whether it came from the east or from the south, arising out of the conflicting statements of those two travellers.

I may add, that the course of the river above 4° N. lat., as described by Dr. Knoblicher, corresponds very closely with that which is marked in the map of 'The Upper Nile according to Dr. Beke's Hypothesis,' published in the *Edingburgh New Philosophical Journal* for October, 1848, vol. xlv, No. 90, in illustration of a paper, 'On the Sources of the Nile in the Mountains of the Moon,' contained in the same number of that journal. I am, &c., CHARLES BEKE.

February 18.

5. *Survey of the Louisiade Archipelago and the Southeast Coast of New Guinea;* by the late Capt. O. STANLEY, R.N., with Notes on the Natural History of the same, by Mr. MACGILLIVRAY, the Naturalist to the Expedition.—(Proc. of Geog. Soc., Athenæum, No. 1214.)—After a passing tribute of respect to the memory of the lamented Mr. Kennedy, murdered, as our readers know, by the natives during his exploration of the Cape York Peninsula—Capt. Stanley (destined so soon to follow him) mentioned the rescue of a Scotch female, the only survivor out of a small vessel wrecked upon the islands, and who had lived four years among their wretched inhabitants. As she had acquired a perfect knowledge of their language, Mr. MacGillivray availed himself of the opportunity of collecting a vocabulary, which has been placed in the hands of Dr. Latham for publication. The most important feature of Guinea seen was a high range of mountains, extending from the Cul de Sac de l'Orangerie to Redscar Point, a distance of nearly 300 miles—some of the peaks of which were more than 10,000 feet above the level of the sea, and one was as much as 12,800 feet. The land both in North Guinea and in the Louisiade is remarkably fertile and very thickly inhabited. The natives are described as treacherous; and on one occasion, when they attacked the boats of the surveying ships and wounded two of the crew, it became necessary to exercise a little judicious ball practice over their heads. The inhabitants appear to be an intermediate race between the Malays and the South Sea Islanders. The islands seem to be of volcanic origin, and are surrounded by a regular barrier reef, which, however, towards the west ceased to be continuous, and permitted an easy passage to the open sea. Although, however, the barrier-reef ceased on leaving the Louisiade, Capt. Stanley found on approaching New Guinea, in order to obtain an astronomical position from whence to carry out the survey, that a ridge of shoal water, *not at all visible from the mast-head*, stretched out about six miles from the land, rendering the navigation here extremely dangerous. After passing this ridge the soundings became more regular. Dense masses of

clouds, hanging over the highlands of New Guinea, prevented their seeing so much of this splendid country as they could have desired, but that portion which was seen is described as surpassing any natural scenery Capt. Stanley had ever met with. The ground appeared to be well cultivated, and numerous small villages along the coast, well sheltered among the trees, gave additional charms to the view. The currents are described as strong and setting in various directions; but the great fact was established by the survey, "that there is a clear channel along the southward of the Louisiade and New Guinea, which, if adopted, will prove by far the safest route for vessels bound to India from New Zealand, and also for those returning during the westerly monsoon in the Arafura Sea." Mr. MacGillivray gave an elaborate description of the collections in natural history made during the survey (shortly to be published); and the movements of the Expedition were further explained by several of the officers on the maps just finished and sent by Admiral Beaufort for that purpose.

6. *On Peat and its Products;* by Prof. BRANDE.—(Proc. Roy. Soc., Jan. 31, Athenæum, No. 1217.)—A peat bog was described as a superficial stratum of vegetable matter, which at different depths is undergoing, or has undergone, various stages of change and decomposition. Its superficial appearance is that of a mass of half decayed mosses, rushes, heath, and grass; the roots having successively died away, though the plants continued to vegetate. The mass is ligneous and imbued with humus and humic acid, among other products of slow decay; and the abundance of moisture pervading the bog affects the character at once of the peat and of the district. The upper layers of the bog are usually loose and fibrous and of a pale brown color. Beneath the surface the density is found to increase, sometimes to a great extent. At last, the distinct characters of the vegetable cease to be discernible, and the mass appears nearly homogeneous and of a dark brown or blackish color. Trunks of trees and some curious geological phenomena occasionally present themselves. A peat district may be regarded therefore as the consolidated produce of enormous forests and fields of vegetation, amounting in the aggregate to millions of acres. In Ireland alone one-tenth of the surface is covered by peat bog, which if removed would exhibit a soil fit for the operations of agriculture. Prof. Brande then invited attention to different samples of peat taken from the upper, middle, and lower portions of the bog. He particularly noticed the tallow peat of the banks of Lough Neagh, which, from the brilliant flame attending its combustion, is sometimes used as a source of light as well as of heat. Peat may be rendered valuable, either—1. From the charcoal which may be obtained from it; or—2. By the various products derivable from what is called its destructive distillation. When it is desired to convert peat into charcoal, the plan adopted by the Irish Amelioration Society is to carbonize blocks of peat, partially dried on trays of wickerwork, in moveable pyramidal furnaces. The charcoal so obtained varies in character with that of the peat which produces it; and when the peat is compressed previous to its carbonization, which may be well effected by means of a machine invented by Mr. Rogers, and which was explained by reference to a diagram, the resulting charcoal exceeds the density of common wood charcoal. In stove-drying, dense peat

loses about one-third, and the light and porous half of its weight: four tons of dried peat will give about one ton of charcoal. The efficacy of this charcoal in the manufacture of iron, in consequence of the small quantity of sulphur it contains, was mentioned; and its deodorizing and purifying qualities experimentally exhibited.—2. The products of the destructive distillation of peat were then described. The elements of peat are essentially those of wood and coal; viz., carbon, nitrogen, hydrogen, and oxygen. If therefore peat were distilled in close vessels, the products obtained, would, as might be expected, resemble the products of a similar operation on coal or wood. Hitherto, however, the expense of such a process in the case of peat has precluded its general adoption. Mr. Reece however has employed for this purpose a blast-furnace, which differs in principle from that in which iron is melted, by having an arrangement to collect the products of combustion; and he has thus succeeded in obtaining ammonia, acetic acid, pyroxylic spirit, tar, naphtha, oils and paraffine, together with large quantities of inflammable gases from the peat. In conclusion, Prof. Brande reviewed the various products of peat and their uses. They appear to be—1. Sulphate of ammonia. This substance is employed in preparation of carbonate and muriate of ammonia, of caustic ammonia, and in the manufacture of manures and fertilizing composts. 2. Acetate of lime, which is in constant demand as a source of acetic acid, and of various acetates largely consumed by the calico printers. 3. Pyroxylic spirit (or wood alcohol) used in vapor lamps, (two of which were exhibited and attention called to the brilliancy of the light afforded,) and in the preparation of varnishes. 4. Naphtha used for making varnishes, and for dissolving caoutchouc. 5. Heavy and more fixed oils, applicable for lubricating machinery, especially when blended with other unctious substances; or as a cheap lamp oil, and as a source of lampblack. 6. Pauraffine. This when fixed with fatty matter forms a material for candles, samples of which were shown consisting of a mixture of paraffine, sperm, and stearine.

7. *On Printing Ferns, Sea-weeds, &c.*, (Athen., No. 1208.)—In the *Athenæum* for December 14th, you have inserted an extract from a Sheffield paper, giving an account of my "Method of producing Plates for Printing Ferns, Sea-weeds," &c. (See p. 280 of this volume.) As that account is very imperfect, will you allow me a small space in your columns to explain my plan more clearly.

A piece of gutta-percha free from blemish, and the size of the plate required, is placed in boiling water;—when thoroughly softened, it is to be taken out and laid flat upon a smooth metal plate, and immediately dusted over with the finest bronze powder used for printing gold letters. The object of this is threefold:—to dry the surface,—to render the surface more smooth,—and to prevent adhesion. The plant is then to be neatly laid out upon the bronze surface, and covered with a polished metal plate, either of copper or of German silver. The whole is then to be subjected to an amount of pressure sufficient to imbed the upper plate in the gutta-percha. When the gutta-percha is cold, the metal plate may be removed, and the fern gently withdrawn from its bed. From the beautiful impression of the fern left in the

gutta-percha a cast in brass may be readily taken. As soon as the surface of the brass cast has been burnished,—of course carefully avoiding the impression,—it is ready for the copper-plate printer. If the printer skillfully mixes the ink to the tint of the fern, a print is obtained scarcely to be distinguished from the plant itself. The novelty of the process consists in causing the plant, so to speak, to engrave itself,—and also in the substitution of a cheap casting in brass for an expensive copper-plate engraving. Electrotype plates may be deposited on the bronzed gutta-percha, and a similar result obtained; but I have found the brass casting to answer equally well, and it has the advantage of being more durable, cheaper, and more expeditious. I send for your inspection, several prints of ferns produced by this process; and have, &c. FERGUSON BRANSON, M.D.

Sheffield, December 18.

8. *Note on Thapsus verbascum;* by H. A. RILEY, (from a letter to the editors, dated Montrose, Pa.)—It may be of interest to announce that a variety of Thapsus verbascum was observed by me the last season bearing white flowers. I found it about four miles east of Montrose, Pa., in the southeast part of Bridgewater and northeast of Brooklyn townships, on the road to the village of Harford. It was intermingled with the common yellow variety, constituting about one-fourth the plants of this species.

9. *Geological Survey of Pennsylvania.*—By a recent act of the Legislature of Pennsylvania, the Geological Survey of the State, so long interrupted for want of Legislative action, is again in the hands of Professor H. D. Rogers. Although not under appointment for some years past, Prof. Rogers has been making progress with his work, and we understand that his Report will soon be completed, after a re-survey of some portions of the state. The work will have a vast economical value, on account of the resources of the country in coal and iron, and a high scientific interest from its embracing a full developement of the carboniferous beds, besides other portions of the geological series. The Report will be fully illustrated by wood-cuts, maps and sections, besides numerous plates of fossils.

10. *Observatory of Altona.*—The place in the Observatory of Altona made vacant by the death of Schumacher, has been filled by the appointment of Dr. Petersen.

11. *Cabinet of Minerals for Sale.*—A valuable collection of minerals foreign and domestic, the property of a deceased physician, containing two thousand specimens. Said collection will be disposed of for money or education. Please address M. Leach, No. 6 Harrison street, south Brooklyn.

12. *American Association for the Advancement of Science.*—The annual meeting of the Association will be held in Albany, in August, commencing with the 3rd Monday of the month. The officers for the year 1851–'52 are as follows:

Prof. L. AGASSIZ, *President.*
" S. F. BAIRD, *Permanent Secretary.*
" W. B. ROGERS, *General Secretary.*
Dr. ALFRED L. ELWYN, Philadelphia, *Treasurer.*

A *semi-annual* meeting will be held in Cincinnati, commencing with the 1st Monday in May, at which time Prof. A. D. Bache, the president of the last annual meeting (1850) presides.

The following is a list of the Local Committee for the meeting at Cincinnati:

Local Committee.

Hon. Jacob Burnet, *Chairman.*
Prof. O. M. Mitchel,
Charles Stetson,
Hon. Timothy Walker,
Prof. Horatio N. Robinson,
John P. Foote, Esq.
Dr. J. A. Warder,
Hon. Nathan Guilford,
Robert Buchanan, Esq.
Rev. Dr. Nathan L. Rice,
E. D. Mansfield, Esq.
Rt. Rev. John B. Purcell,
Dr. Joseph Ray,
Prof. Benjamin Silliman, Jr.

Local Secretary.

Dr. Thomas Rainey.

We cite the following from the circular recently issued by the Local Secretary at Cincinnati:

The meeting of the Association will open at 3 o'clock, P.M., on Monday.

The Secretary and a member of the Local Committee will be in attendance at the Burnet House, from Saturday until Monday afternoon, to direct members to the quarters secured for them; the Local Committee having provided for the gratuitous entertainment of all members attending. It is desirable that the members, as they arrive in the city, should report themselves at the place above noticed.

A book of registration will be opened at the principal place of meeting.

Places of Meeting.—All *General Meetings* will be held in College Hall, on Walnut street; *Section Meetings* will be held in adjacent rooms in the College Building.

Travelling Facilities.—The Secretary has been enabled to secure the privilege of transit of all members of the Association, who may pass over Lake Erie, or over the railroads of Ohio, at half the usual rates. Similar courtesies will doubtless be accorded by other lines of travel; all of which will be duly published in the public journals some weeks previous to the meeting.

13. *Munificent Donation to Dartmouth College.*—A legacy of $50,000 has been left to Dartmouth College for founding a School of Arts, by Mr. Abiel Chandler of Boston. Mr. Chandler was a native of Concord, N. H., and a graduate of Harvard in 1806.

14. Prof. Silliman and his son, Prof. Silliman, Jr., left the country on the 5th of March for England and the Continent, to return early in autumn. They reached Liverpool on the 16th.

OBITUARY.

C. W. B. Goldschmidt, (from a letter addressed by B. A. Gould, Jr., to one of the editors of this Journal.)—Death has been busy of late among the astronomers and mathematicians of Germany. The venerable and good Schumacher has passed away, and we have just been called upon to lament the loss which science has sustained in the decease of the

illustrious Jacobi at Berlin. The last mail has now brought intelligence of the death of Prof. Goldschmidt, of the Göttingen Observatory. You will doubtless be glad to give place in your Journal for a line of tribute to his memory, from one who knew and loved him well.

C. W. B. Goldschmidt was Extraordinary Professor of Astronomy in the University of Göttingen, and assistant to Gauss at the Observatory in that place; filling in both respects the position previously occupied by Prof. Harding, the author of the Celestial charts, and the discoverer of the planet *Juno*.

He was nurtured, like Jacobi, in the Hebrew faith, but his character was eminently conspicuous for the Christian virtue—love to God and man. Though perhaps not a great astronomer, he was an enthusiastic and a laborious one; and in his peculiar position, rendered unquestionably more essential and lasting services to astronomy, than many a man whose name will occupy a more conspicuous place in the annals of science. If the earnest devotion of a life to his favorite studies, and the sincerest efforts uprightly and conscientiously to fulfill the duties assigned him in the great march of scientific progress, can give a claim to the gratitude and remembrance of mankind, Goldschmidt's name will be long honored by those who never knew him. It will not easily be forgotten by those whose privilege and joy it was to call him their friend.

Among the scientific labors of Prof. Goldschmidt, I may mention his labors in connection with Gauss and Weber's *Resultate des Magnetischen Vereins*, and especially in preparing the Atlas of Terrestrial Magnetism, which accompanies that work; his discovery of the periodicity of the comet generally known as "Faye's;" his investigation of the minimum surfaces of rotation of curves about a fixed axis; and numerous computations of planetary and cometary orbits.

His death was like his life—quiet and peaceful. He had long suffered from the consequences of an enlargement of the heart; and on the morning of Feb. 15th, he was found in his bed, sleeping the sleep that knows no waking.

William Sturgeon.—Mr. Sturgeon, the eminent electrician, died on the 8th of December last. His researches have given his name a prominent place in the history of Science in England. Born of humble parents at Whittington, near Lancaster, in 1783, he was apprenticed early in life to a shoemaker. Subsequently he entered the Westmoreland militia, and after two years' service volunteered into the royal artillery, in which corps he served about twenty years. During his connection with the artillery, his attention was awakened by a terrific thunder-storm to thoughts on the mysterious power that was exhibited before him; and he resolved to study its nature. Books about him were few, and his early education deficient; but with the energy of genius, he took hold of the science from its foundation, acquired a good knowledge of mathematics, made much proficiency in Greek, Latin, French, German and Italian, that he might not be excluded from any of the sources of knowledge, and thus prepared, entered on the study of Natural Philosophy and especially the departments of electricity and magnetism. Such progress amid the constant and wearying routine and dissipating tendencies of military life, exhibits the high order of his

mind. His contributions to science, the fruits of this preparation and of his subsequent investigations, were exceedingly numerous. The following letter from Mr. J. P. Joule of Manchester, briefly announces some of the prominent results, and with slight exceptions correctly so.

"I have sifted Mr. Sturgeon's claims to the utmost. I have examined all the periodicals likely to throw light upon the history of electro-magnetism, and find that Mr. Sturgeon is, without doubt, the originator of the electro-magnet, as well as the author of the improved electro-magnetic machine. The electro-magnet described by Mr. Sturgeon, in the Transactions of the Society of Arts for 1825, is the first piece of apparatus to which the name could with propriety be applied. Arago, and Ampere, and Davy had already, it is true, magnetized steel needles by passing currents of electricity along spirals surrounding them, but it does not appear that they observed the phenomena with iron needles, nor that they had any knowledge of the suddenness with which the polarity of soft wrought iron might be reversed by a change in the direction of the current. It appears, therefore, quite clear that to Mr. Sturgeon belongs the merit of producing the first electro-magnet constructed of soft iron, as well as that of ascertaining its peculiar and most remarkable properties. *Hence it was that M. Jacobi of St. Petersburgh, claimed for Mr. Sturgeon, in conjunction with Prof. Œrsted, the discovery of the electro-magnetic engine.* Mr. Sturgeon's claims with regard to the magneto-electrical machine appears to me to be equally well established. He was the first who devised and executed an apparatus for throwing the opposing currents into one direction, thus accomplishing for this machine exactly what Watt accomplished for the steam engine. Besides this, he is beyond dispute, the author of the system of solid brass disks and insulators, going by the name of "commutator" on the continent, and "unitrep" in America; an apparatus now universally employed in every magneto-electrical machine. Mr. Sturgeon was without doubt, the constructor of the first rotary electro-magnetic engine.*

"The use of amalgamated zinc plates in the voltaic battery was originated by Mr. Sturgeon. It is an improvement of such value that it has been universally adopted ever since, although all other arrangements of equal date have been superseded.

"Mr. Sturgeon's discoveries in the thermo-electricity and magnetism of homogeneous bodies are very important, and have placed his name higher than that of any other philosopher who, after Seebeck, has cultivated thermo-electricity.

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* It appears that Mr. Sturgeon made the first rotary electro-magnetic engine; but this was after Prof. Henry had published an account of his reciprocating electro-magnetic engine, which is upon the same principle with Mr. Sturgeon's instrument, the motion being reciprocating instead of rotary. With regard to the improvement of uniting the opposing currents of magneto-electric machines into one common current, this was made by Prof. Page, before it was *published* by Mr. Sturgeon, but not till after Mr. Sturgeon's result had been obtained, as appears from his references. But as to the means by which this was affected in Prof. Page's machine, to which he gave the name of "*unitrep*," (the means now universally in use,) we believe Prof. Page to have been the first in introducing and describing it. His paper was published in this Journal five months before the publication by Mr. Sturgeon of his method.

"The above is only a very imperfect abstract of a small part of Mr. Sturgeon's discoveries and improvements in magnetism, electricity, and the kindred sciences. Though not himself the author of extensive generalizations, he has been signally useful in preparing the way for them, and in carrying them out practically; and I know not of one individual who, under equal or even less disadvantages, has contributed so eminently to the advancement of these highly interesting and useful sciences. (Signed,) JAMES P. JOULE."

Soon after he left the army, Mr. Sturgeon was appointed Professor of Natural Philosophy in the Military Academy at Addiscombe, and subsequently had the superintendence of the Victoria Gallery of Science at Manchester. The discontinuance of this Institution deprived him of his means of subsistence, and he was for a while thrown for resources on a precarious income from voluntary lectures. Less than two years before his death he was placed by Lord John Russell on the civil list for a pension of £50 per annum. A biographical notice in the Manchester Examiner and Times, from which the facts here given are taken, observes, "The death of this distinguished philosopher has created a hiatus that will not soon be filled up; and his loss is greater to his friends, in that, to great scientific attainments, he united a cordiality, and warm friendliness of character, that endeared him to all who knew him well. He was, in all respects, a fine, frank, manly fellow—one of the great original-minded men, of which Lancashire has produced so many, and of whom she may well be proud."

Dr. LINCK.—This eminent botanist of the University of Berlin, died on the 1st of January last, in his 82nd year. Dr. Linck was director of the Royal Botanical Garden in Berlin.

V. BIBLIOGRAPHY.

1. *Report of the Secretary of the Treasury on the Coast Survey*, dated Treasury Department, Feb. 15, 1851.

Report of Prof. Alexander D. Bache, Superintendent of the Coast Survey, showing the progress of the work for the year ending October, 1850.

The first of these Reports, from the Hon. Secretary of the Treasury, contains the results of his enlightened consideration of the question whether the progress of the Coast Survey would be promoted by its transferal to the Navy Department. His conclusion is given in a decisive manner, in the opening paragraphs of the Report, in which he says that he has "come to the full conviction that to transfer the work to the Navy Department would be to destroy it, by disorganizing the present admirably devised system, which, for efficiency and economy, can scarcely be improved; and which, in its results, has never been surpassed.

"This organization combines all the efficiency which can be derived from the army, the navy and the science of the country, assigning to each its appropriate sphere of action.

"Under this organization, the most rigid control is exercised over the expenditures, and a greater amount of work produced in proportion to the cost, than in any other operation of the same kind ever undertaken.

"Under this organization three-eights of the coast of the Atlantic and Gulf of Mexico have been surveyed, and, at the present rate of progress, the remainder will be completed within twelve to fifteen years, while the survey of the Pacific coast is rapidly advancing."

These and other points are discussed in the Report and presented in a forcible light, and due honor is bestowed upon the present illustrious head of the Coast Survey, who is preëminently fitted for the situation he holds.

The Report of the Hon. Secretary of the Treasury will have a hearty response from all who regard the true welfare and honor of the country.

The Report by Prof. Bache contains much information of interest which we must pass by for the present.

2. *The Annual of Scientific Discovery, A Year-Book in Science and Art*, exhibiting the most important Discoveries and Improvements in Mechanics, Useful Arts, Natural Philosophy, Chemistry, Astronomy, Meteorology, Zoology, Botany, Mineralogy, Geology, Geography, Antiquities, together with a list of recent Scientific publications, a classified list of Patents, Obituaries of eminent scientific men, an Index of important Papers in Scientific Journals, Reports, etc.; edited by DAVID A. WELLS, A. M., of the Lawrence Scientific School, Cambridge, and GEORGE BLISS, Jr.—428 pages, 12mo. Boston, 1851. *Gould & Lincoln.*—This volume ranges over all departments of science, culling from the researches of the year past, the more important facts and discoveries, especially those which bear upon the progress of the age in the useful arts, though not to the rejection of subjects of more purely scientific character. The selections have been made with discrimination, and evidently with much labor and study. The volume commences with a condensed review of the principal events in the advancement of science through the year 1850, occupying 15 pages; about 100 pages are next devoted to Mechanics, and the Useful Arts, and there are few concerned in any of the Arts that will not find some facts of special importance to them. Natural Philosophy and Chemistry occupy the next 150 pages; Geology, Zoology and Botany about 120 pages, and Astronomy, Meteorology, Geography and Antiquities the following 25 pages. This work is one of the most important means of diffusing knowledge through the country which has been projected, and will be found full of instruction and interest to the general reader, as well as to those interested in science.

3. *Principles of Zoology*, touching the Structure, Developement, Distribution and Natural Arrangement of the Races of Animals, living and extinct, with numerous illustrations. Part I, Comparative Physiology, for the use of Schools and Colleges, by LOUIS AGASSIZ and A. A. GOULD. Revised edition, 250 pp. 12mo., Boston, 1851. Gould & Lincoln.—Prof. Agassiz's thorough knowledge of every branch of zoology, and his facility in explaining to the unlearned the profoundest principles of the science, as well as the ability of Dr. Gould, commend this text-book to all who would study the subject of which it treats. A hand familiar with the minutest details, and at the same time with the highest generalizations, is every where to be seen through its pages. The chapter on the geological succession of animals contains original views of deep importance to geological science as well as to zoology.

4. *Smithsonian Institution Publications.*—The Smithsonian Institution, under the wise policy which has been adopted, and the general superintendence of Prof. Henry, has already made good progress towards carrying out the will of the testator, in the diffusion of useful knowledge. The amount of money injudiciously expended in the building, has however limited much the means of the Institution. Still the increase of the library and the publication of memoirs are going forward.

The following is a list of its publications, from Prof. Baird:—

I. *In Quarto.*—(1.) Ancient Monuments of the Mississippi Valley, forming Vol. I, of the Smithsonian Contributions to Knowledge.

(2.) Researches relative to Neptune, by Sears C. Walker.
(3.) Ephemeris of Neptune for 1848, " "
(4.) " " 1849, " "
(5.) " " 1850, " "
(6.) " " 1851, " "
(7.) Occultations for 1848. Computed by John Downes.
(8.) " 1849. " "
(9.) " 1850. " "
(10.) " 1851. " "

(11.) On the Vocal Sounds of Laura Bridgeman, by Dr. Francis Lieber.

(12.) On the Physical Geography of the Mississippi Valley, by Charles Ellet, Jr.

(13.) On Mosasaurus and the allied Genera, by Dr. R. W. Gibbes.

(14.) Aboriginal Monuments of the State of New York, by E. G. Squier.

Microscopical Examination of Soundings made by the U. S. Coast Survey, by Prof. J. W. Bailey.

Microscopical Observations made in the Southern States, by Prof. J. W. Bailey.

(15.) On the Explosiveness of Nitre, by Dr. Hare.

The preceding, excepting 1, 3, 7, 8, 9, constitute the second volume of Smithsonian Contributions.

(16.) Hints on Public Architecture, by R. D. Owen, Esq. This was published by the Building Committee, but is not one of the series of Contributions.

II. *In Octavo.*—Annual Reports for 1846, 1847, 1848, 1849, (1850 in press.) Report on the Discovery of Neptune, by Dr. B. A. Gould, Jr.

Several 4to. Memoirs are in hand and will be put to press very shortly. Also, 8vo. Reports on the progress of several branches of science.

5. *An Elementary Treatise on Statics;* by Gaspard Monge, with a biographical notice of the Author. Translated from the French by Woods Baker, A.M., of the United States Coast Survey. 216 pp. 12mo. Philadelphia, 1851. E. C. and J. Biddle.—This treatise contains a concise and perspicuous exposition of the principles of Theoretical Mechanics, well adapted for instruction in the higher institutions by its clear and rigorous style of demonstration, and fitted for promoting real progress in the mechanical arts, by its thorough exhibition of the great fundamental truths upon which they depend.

6. *Rainey's Improved Abacus:* An explanatory treatise on the Theory and Practice of Arithmetic and Mensuration; by THOMAS RAINEY. 313 pp. 16mo. Cincinnati, 1850, E. D. Truman.—This is a work of practical value in all kinds of calculations in mercantile and every day life. Thirty pages are devoted to figures of coins.

7. *Lichenes Americæ Septentrionalis Exsiccati. Fascic. I. and II.;* curante EDVARDO TUCKERMAN, A.M., Cambridge, Mass.—This volume is in fact a herbarium of Lichens in small 4to, labelled throughout, and therefore a most desirable work to the student of Cryptogamous plants, and to all general libraries. The department has long been the special study of Mr. Tuckerman, and the names assigned by him to the specimens are therefore full authority. The work is better than a book of engravings to the student, as it contains the objects themselves, and it has a standard value, exhibiting the characters and names of well established species for future comparisons in the farther prosecution of the science. The volume contains fifty species and varieties. Mr. Tuckerman's "Synopsis of the Lichens of New England" was noticed in the 5th volume (1848) of this Journal.

8. *The Old Red Sandstone or New Walks in an Old Field;* by HUGH MILLER, author of "Footprints of the Creator," &c. From the 4th London edition; 288 pp. 12mo, illustrated by numerous engravings. Boston: 1851. Gould & Lincoln.—Science has never been rendered more entertaining than in the works of Hugh Miller: and it is not an extraneous entertainment, but that proceeding from the exalted character and interest of the subject itself, through the workings of a mind that appreciates nature in her highest moral and physical aspects. With the author, stones seem to be as full of poetry as his own cultivated mind, and both appear as the eloquent expositors of the thoughts of God. "The Old Red Sandstone" and the "Footprints of the Creator," we would earnestly commend to all, scientific and unscientific. They contain the results of original research in science that may enlighten the most learned; at the same time, the simple glowing style of the author, his clear and vivid illustrations, and the ennobling views of truth which he presents, admirably fit these volumes for general instruction and improvement. The theologian may here learn rightly to apprehend God in his works; and the man of science, clearly to discern the God of revelation in nature.

REPORT OF THE BOARD OF TOPOGRAPHICAL ENGINEERS on the Inundations of the Lower Mississippi, by S. H. LONG, Lieut. Col., and A. A. HUMPHREYS, Capt., Members of the Board, dated Dec. 18, 1850, and Reported by the Secretary of War to the Senate, and ordered to be printed, Jan. 17, 1851.—EX. Doc. No. 13, 2d Session 31st Congress.

J. W. ALEXANDER, Esq.: A Universal Dictionary of Weights and Measures, Ancient and Modern. Super-royal 8vo. *Baltimore*, 1851. Wm. Miniſie & Co. Cloth, $1 50.—A work of great research and value.

F. OVERMAN: Practical Mineralogy. 230 pp. 12mo. *Philadelphia*, 1851. Lindsay & Blakiston.

ANDREW PRITCHARD: History of Infusoria, living and fossil.—In course of preparation a new and greatly enlarged edition. Price to subscribers 21*s.*

FREDERICK DIXON, Esq., F.G.S.: The geology and tertiary fossils of the Tertiary and Cretaceous formations of Sussex. Royal 4to. *London.* 63*s.*

GEORGE JOHNSTON, M.D., LL.D.: Introduction to Conchology, or Elements of the Natural History of Molluscous Animals. *London*, 1850. Van Voorst.

ROBERT HUNT: Elementary Physics; fcap, 8vo, with numerous wood-cuts. *London*, 1851. Reeve & Benham.

WM. THOMPSON, Esq.: The Birds of Ireland; 3d and concluding volume, nearly ready. *London*. Reeve & Benham.

Prof. M'COY: The British Palæozoic Fossils, added by Prof. Sedgwick to the Woodwardian Museum. In royal 4to, with numerous plates. Part I, ready. Reeve & Benham.

Mrs. HUSSEY: Illustrations of British Mycology, 2nd ser. In royal 4to, with numerous colored plates. Part iii, just published. *London*. Reeve & Benham.

JOHN TIMBS: Year-Book of facts in Science and Arts for 1851, exhibiting the most important discoveries and improvements of the past year in all branches of Science and the Arts. *London*. 5*s*.

M. BORRELL: The Numismatist—a monthly publication exclusively devoted to the familiar illustration of the science of Numismatography. Begun March 1st. *London*. J. Hearne.

SPICILEGIUM NEILGHERRENSE, or a selection of Neilgherry plants drawn and colored from nature. 4to, with 150 colored plates. *Madras*, 1846–1850. 4*l*. 10*s*.

PROCEEDINGS OF BOSTON SOC. NAT. HIST.—*December*, 1850. p. 339. On the age of the red sandstone of the Connecticut valley; *Wells*.—p. 342. New Medusa, Rhacostoma atlanticum; *Agassiz*.—p. 343. New shells of Exploring Expedition (genera Mytilus, Pecten, Ostræa, Terebratula, Mactra); *A. A. Gould*.—p. 348. Development of Planocera elliptica; *Girard*.—Observations on fishes and other animals of Mammoth Cave; *J. Wynan*.—p. 354. On supposed parasites of Hydra; *Agassiz*.—p. 356. Observations on the Naiades; *Agassiz*.—p. 357. Origin of deposits of marine shells in Maine, on the St. Lawrence, and on Lake Champlain; *Desor*.—p. 358. Origin of the sands of the Ridge Road from Rochester to Lewiston, N. Y.; *Desor*.—p. 359. Sixteen new species of Melania; *A. A. Gould*.—p. 363. Observations on Planarian Worms, with descriptions of new species of Echinoderms; *Girard*.

PROCEEDINGS ACAD. NAT. SCI. PHILADELPHIA. *January*, 1851.—p. 139. On the crossing of the Dog and Wolf; *S. G. Morton*.—p. 141. Habits of Rocky Mountain Swallow; *J. P. Hazard*. *February*.—p. 144. New Jersey Meteorite; *C. U. Shepard*.—p. 145. On Hair; *P. A. Browne*.—p. 147. A new species of Jackal from near Fort Gibson, (Canis frustror); *S. W. Woodhouse*.—p. 149. Sketch of the Birds of the Genera Vireo, *Vieillot*, and Vireosylvia, *Bonaparte*, and list of known species with descriptions of three new; *J. Cassin*.—p. 154. Two new Birds of the Genera Galbula and Bucco, *Briss.*, in collections of Acad.; *J. Cassin*.—p. 155. New species of Entozoa; *J. Leidy*.—p. 156. On two Mexican Wolves, Canis Mexicanus and the Canis frustror; *Dr. Berlandier*.—This number of the Proceedings contains two plates, Pl. 3, of Emberiza bilineata, *Cassin*, and Pl. 4, Emb. Belli, *Cassin*.

ASTRONOMICAL JOURNAL, Contents for NO. 21, Jan. 18.—Continuation of the Investigation of Change of Place in the fixed Stars; *E. Schubert*.—From a letter of Professor Goldschmidt to the Editor.—From a letter of Mr. Graham to the Editor.—Observations of Hygea, made with the Filar-Micrometer of the Washington Equatorial; *J. Ferguson*.—Elements and Ephemeris of Clio.—Egeria.—NO. 22, February 14.—Elements and Ephemeris of Clio.—From a letter of Professor Hubbard to the Editor.—Zodiac of Clio.—Occultations of Stars observed at the Cambridge Observatory in the years 1846, 1847, 1848, 1849, 1850.—Death of Prof. Schumacher.—NO. 23, March 14.—Observations on Hebe, Iris, and Egeria, made with the Filar-Micrometer of the Washington Equatorial; *J. Ferguson*.—Elements and Ephemeris of Iris, for 1852; *E. Schubert*.—Observations of the First Comet of 1850, made at Hudson, Ohio; *E. Loomis*.—On the Similarity of Arrangement of the Asteroids and the Comets of short period, and the possibility of their common origin; *S. Alexander*.

NOTE.—*Professor Page's Electro-magnetic Locomotive.*—We learn from the National Intelligencer, that on Thursday last, [Mar. 27,] Prof. Page made a preliminary trial on the railroad, for the purpose of testing the best mode of attaching the battery, which seems to be a difficult point, owing to the jostling and oscillations of the locomotive. It was run out over two miles, and the best speed on a straight track was ten miles an hour. The locomotive weighs ten and a half tons, and has five feet drivers, with two feet stroke. The Intelligencer says it looks exactly like a passenger car.

Index photographed at the
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